FINANCING RURAL ENERGY PROJECTS IN DEVELOPING COUNTRIES: A CASE STUDY OF NIGERIA

By:

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DECLARATION

I hereby declare that I am the author of this thesis; that unless otherwise stated, all references cited have been consulted by me and duly acknowledged with their sources cited; that no portion of work referred to in this thesis has been submitted in support of an application for another degree of qualification in this or any other university or Institute of Learning; and that this work was solely conducted during my registration for the award of Doctor of Philosophy at De Montfort University, under De Montfort University Supervision.

Signed………………………… Date…………………………………
Sanusi Mohammed Ohiare

DEDICATION

To:

Almighty Allah, Most Gracious, Most Merciful,

My Parents, Senator M.S. Ohiare and Hajia Aminat Ohiare,

And

The over 1.3 billion rural poor that currently don't have access to electricity in the world.

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ABSTRACT

The recent awareness created by the UN Secretary General on the need to provide universal energy for all by 2030, which culminated in the declaration of 2012 as the “International Year of Sustainable Energy for All”, laid particular emphasis on the challenge of funding rural electrification in developing countries, and the need for innovative ways and financing options to be developed at national, regional and global levels towards achieving the ‘energy for all’ target of 2030. This research, as part of efforts towards remedying the rural electrification scourge of developing countries, particularly in Nigeria, provides financing options for rural electrification as far as the Nigerian Electricity Supply Industry (NESI) context is concerned.

The study does this by first identifying appropriate least-cost electrification supply mode (Grid, Mini-grid and Off-grid), and estimating the financing requirement for providing universal energy access to rural Nigeria by 2030, using a spatial electricity planning model called the *‘Network Planner’*. Results from this research show that by the end of the seventeen year planning period (2013-2030), 98% of currently un-electrified communities will be viable for grid expansion, while only 2% will be mini-grid compatible. This is based on a proposed MV line extension of 12,193,060 metres or (12,193 kilometres), LV line length proposal of 711,954,700 metres or (711,954 kilometres), and an estimated total cost of US$34.5 billion investment within the planning period. More so, a total number of 28.5 million households are to be electrified by 2030, which is equivalent to an estimated 125million people to be provided electricity by 2030.The analysis was done for the 36 states of Nigeria and the entire country, using data from the 774 Local Government Areas of Nigeria.

In addition to the Rural Electrification Fund (REF) of the FGN, which gets funding from yearly budgetary allocations from the FGN, fines obtained by NERC, surplus appropriation, interests accruing to the REF and donations from various sources, the following financing options were recommended for rural electrification in Nigeria: the establishment of a Renewable Energy Development Charge (REDC); the establishment of a Rural Electrification Fund Tax (REFT) Law; adopting rural electrification as part of Corporate Social Responsibilities (CSR) for oil and other companies; Exploring the option of Crowd-funding; and Establishing a Renewable Energy Private Equity Fund in Nigeria.

Keywords: Financing, Rural Electrification, Options, Nigeria.

Contents

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Abbreviation	Term
ABC	Agricultural Bank of China
ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
AFC	Alkaline Fuel Cell
AfDB	African Development Bank
AFP	Agence Francaise de Development
AHP	Analytical Hierarchy Process
AIP	Africa Infrastructure Program
AMORE	Alliance for Mindanao Off-grid Renewable Energy
ANEEL	National Electricity Regulatory Agency, Brazil
ARE	Alliance for Rural Electrification
ASER	Senegalese Agency for Rural Electrification
BCF	Biogas Credit Fund
BOC	Bank of China
BP	British Petroleum
BPE	Bureau of Public Enterprise
BRAC	Bangladesh Rural Advancement Committee
BRI	Bank Rakyat Indonesia
CBN	Central Bank of Nigeria
CCB	China Construction Bank
CHINAOIL	China United Oil Corporation
CDM	Clean Development Mechanisms
CIA	Central Intelligence Agency
CNCC	China National Coal Corporation
CNCIEC	China National Coal Industry Import & Export Corporation
CNLCMDC	China National Local Coal Mine Development Corporation
CNNIC	China National Nuclear Industry Corporation
CNOOC	China National Offshore Oil Corporation
CNPC	China National Petroleum Corporation
CNPIC	China National Power Industry Corporation
CREIA	Chinese Renewable Energy Industries Association
CSPG	China South Power Grid
CO_2	Carbon Dioxide
CT	Combustion Turbines
CTF	Clean Technology Fund
DB	Deutsche Bank
DC	Direct Current
DG	Distributed Generation
DANIDA	Danish International Development Agency
DisCo	Distribution Company
DMFC	Direct Methanol Fuel Cell
DSM	Demand-Side Management
ECG	Electricity Company of Ghana
ECN	Energy Commission of Nigeria
ECN	Electricity Corporation of Nigeria
ECOWAS	Economic Community of West African States
EIA	Energy Information Administration

ENCON	Energy Conservation Promotion Fund, Thailand
EPIC	Electric Power Implementation Committee
EPSRA	Electricity Power Sector Reform ACT
EPSRC	Electric power Sector Reform Committee
ESCOM	Energy Service Company
ESMAP	Energy Sector Management Assistance Program
EU	European Union
EUEI PDF	EU Energy Initiative – Partnership Dialogue Facility
FAO	Food and Agriculture Organization of the United Nations
FC	Fuel Cells
FCT	Federal Capital Territory
FCO	Foreign and Commonwealth Office
FDI	Foreign Direct Investment
FGN	Federal Government of Nigeria
FRN	Federal Republic of Nigeria
GBP	Great British Pounds
GCH	Greater China Fund
GDP	Gross Domestic Product
GEF	Global Environmental Fund
GenCo	Generation Company
GHGs	Greenhouse Gases
GIEK	Guarantee Institution for Export Credit, Norway
GIS	Geographic Information System
GPOBA	Global Partnership on Output-based Aid
GVEP	Global Village Energy Partnership
GW	Gigawatts
GWh	Gigawatt Hour
HOGA	Hybrid Optimisation by Genetic Algorithms
HOMER	Hybrid Optimization Model for Electric Renewables
IAEA	International Atomic Energy Agency
ICBC	Industrial & Commercial Bank of China
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IDB	Inter-America Development Bank
IEA	International Energy Agency
IFC	International Finance Corporation
IFS	International Financial Statistics
ILO	International Labour Organization
IMF	International Monetary Fund
INEP	Integrated National Electrification Programme
IOC	International Oil Company
IPP	Independent Power Producers
IREDA	India Renewable Energy Development Agency
IRP 2010	Integrated Resource Plan- Electricity 2010
IRR	Internal Rate of Return
Kg	Kilograms
Km^2	Square kilometres
KV	kilovolts
KW	kilowatt
KWh	Kilowatt Hour
KWp	kilowatt-peak

LGA	Local Government Area
LNG	Liquefied Natural Gas
LnC	Light in the Countryside, Brazil
LPG	Liquefied Petroleum Gas
LpT	Light for All, Brazil
Lv	Low Voltage
Mbpd	Million barrels per day
MCDM	Multi-criteria decision making method
MCDM-RES	Multi-criteria Decision Making for Renewable Energy Sources
MCFC	Molten Carbonate Fuel Cell
MCI	Ministry of Coal Industry
MDGs	Millennium Development Goals
MEI	Ministry of Energy Industry
MEP	Ministry of Electric Power
MEP	Missionary Electrification Project, Philippine
MFP	Ministry of Fuels & Power
MPI	Ministry of Petroleum Industry
MESITA	Malaysia Electricity Supply Industry Trust Account
MF	Microfinance
MFBs	Microfinance Banks
MFIs	Microfinance Institutions
MID	Mean Inter-Household Distance
MIGA	Multilateral Investment Guarantee Agency
MME	Ministry of Mines and Energy, Brazil
MT	Micro Turbines
Mtoe	Million Tonnes of Oil Equivalent
Mv	Medium Voltage
MW	Megawatts
MYTO	Multi-Year-Tariff-Order
NAPTIN	National Power Training Institute of Nigeria
NBS	Nigerian Bureau of Statistics
NCP	National Council on Privatisation
NCS	Nigerian Customs Service
NDA	Niger Dams Authority
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NEC	National Energy Commission
NELMCO	Nigerian Electricity Liability Management Company
NEP	National Energy Policy
NEPA	National Electric Power Authority
NEPP	National Electric Power Policy
NER	National Electricity Regulatory
NES	National Electrification Scheme, Ghana
NESCO	Nigeria Electric Supply Company
NESI	Nigerian Electricity Supply Industry
NFRD	National Fund for Regional Development
NGOs	Non-governmental Organisations
NDHS	Nigeria Demographic and Health Survey
NDPHC	Niger Delta Power Holding Company
NERC	Nigerian Electricity Regulatory Commission
NIPP	National Integrated Power Projects

NIS	National Interconnected System
NIZ	Non-Interconnected Zones
NLSS	Nigerian Living Standard Survey
NNPC	Nigeria National Petroleum Corporation
NP	Network Planner
NPA	Nigerian Ports Authority
NPBD	National Project on Biogas Development, India
NPC	National Population Commission
NRE	National Rural Electrification Program
NREL	National Renewable Energy Laboratory
O & M	Operation and Maintenance
OECD	Organisation for Economic Cooperation and Development
OFID	OPEC Fund for International Development
ONEM or MO	Operator of the Nigerian Electricity Market or Market Operator
OPEC	Organisation of Petroleum Exporting Countries
PAFC	Phosphoric Acid Fuel Cell
PBS	Palli Bidyut Samities
PDF	Power Development Fund, Nepal
PEA	Provincial Electricity Authority, Thailand
PEMFC	Proton Exchange Membrane Fuel Cell
PHCN	Power Holding Company of Nigeria
PhD	Doctor of Philosophy or Philosophiae doctor
PIB	Petroleum Industry Bill
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PRG	Partial Risk Guarantee
PV	Photovoltaic
RE	Renewable Energy
RE	Reciprocating Engines
REA	Rural Electrification Agency
REB	Rural Electrification Board
RECS	Rural Electrification Collective Scheme, Botswana
REF	Rural Electrification Fund
REP	Rural Electrification Program
REPF	Rural Electrification Programme Fund
REPP	Renewable Energy Power Program, Philippine
RETs	Renewable Energy Technologies
RERED	Renewable Energy for Rural Economic Development
RMB	Renminbi
SEA	South-East Asia
SEEDS	Sarvodaya Economic Enterprises Development Services, Sri-Lanka
SEI	Stockholm Environment Institute
SEIC	State Energy Investment Corporation
SERC	State Electricity Regulatory Commission
SETC	State Economic & Trade Commission
SGCC	State Grid Corporation of China
SHP	Small Hydropower
SHSs	Solar Home Systems
SIDA	Swedish International Development Agency
SINOCHEM	China National Chemicals Import & Export Corporation
SINOPEC	China Petroleum & Chemical Corporation

SMEs	Small and Medium-sized Enterprises
SNV	Netherlands Development Organisation
SO	System Operator
SOFC	Solid Oxide Fuel Cell
SPC	State Planning Commission
TANESCO	Tanzania Electricity Supply Company Limited
TCN	Transmission Company of Nigeria
TSP	Transmission Service Provider
TVEs	Township and Village Enterprises
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational and Cultural Organisation
UNICEF	United Nations International Children Emergency Fund
UNIDO	United Nations Industrial Development Organization
US	United States
USD	United States Dollar
USAID	United States Agency for International Development
USD	United States Dollar
VRA	Volta River Authority, Ghana
WB	World Bank
WEO	World Energy Outlook
WHO	World Health Organisation

CHAPTER ONE
INTRODUCTION

1.1 Background and Statement of Problem

Energy is no doubt one of the major drivers of socio-economic development of every nation, and its impact in this regard cannot be overemphasized. In comparison to other forms of energy, access to electricity has a huge role. The contribution of electricity to various sectors and facets of human endeavour such as education, health, agriculture and all households has made life much easier. Access to electricity in rural areas of developing countries has helped in increasing agricultural productivity, crop irrigation, preservation of farm produce and agro-processing (Haanyika, 2006). It also helps with the reduction of rural-urban migration in search of employment and better livelihoods. Thus, access to electricity is very essential in our daily lives as well as crucial to economic growth and development.

However, access to energy in most parts of the world especially in the rural areas of developing countries is often elusive. A substantial part of the world's population still lack access to modern energy, and the most widely quoted figure for those people living in developing countries without access to electricity services is estimated to be over 1.3 billion[1], 85% of them reside in rural areas of Asia and Sub-Saharan Africa. Table 1.1 below gives a more vivid picture of this problem.

[1]IEA (2011), Energy for all: financing access for the poor, special early excerpt of the world energy outlook 2011. Paris: International Energy Agency.

Table 1.1: World Electrification Rate by Regions, 2011

	Population without electricity (millions)	Electrification rate (%)		
		Total %	Urban %	Rural %
North Africa	1	99.0	100	98.4
Sub-Saharan Africa	599	32.0	55.0	18.0
Africa	**600**	**43.0**	**65.0**	**28.0**
India	306	75.0	94.0	67.0
Rest of developing Asia	309	87.0	95.0	80.0
Developing Asia	**615**	**83.0**	**95.0**	**75.0**
Middle East	19	91.0	99.0	76.0
Latin America	24	95.0	99	81.0
Developing countries	**1,257**	**76.5**	**90.6**	**65.1**
Transition economies & OECD	**1**	**99.9**	**100.0**	**99.7**
World	**1,258**	**81.9**	**93.7**	**69.0**

Source: IEA (2013).

According to the International Energy Agency-IEA (2013), Sub-Saharan Africa only has an electrification rate of 32%, while 80% of its people use biomass for cooking. If no concerted efforts and policies are put in place immediately, it is feared that in 2030, the number of people that will continue to use biomass shall increase to 2.8 billion, from the current 2.7 billion people, while the number of people without access to electricity will only slightly drop to 1.2 billion as projected in 2030 by IEA (2010).

Table 1.2: Twelve Most Concentrated Countries without Access to Electricity, 2011

Country	Population Rank	Population Without electricity access (Million)	Share of Population without access (%)		
			Urban	Rural	Total
India	2	306	6.1	33.1	24.7
Nigeria	7	85	39	65	52
Indonesia	4	66	15	40	27
Ethiopia	14	65	15	89	77
DR Congo	19	62	74	100	91
Bangladesh	8	61	10	52	40
Pakistan	6	56	12	43	31
Tanzania	30	39	54	96	85
Kenya	31	34	42	93	81
Uganda	36	30	45	93	85
Myanmar	24	25	11	71	51
Afghanistan	46	23.3	78	88	85.6

Source: IEA, 2013

From table 1.2 above, it is observed that majority of those lacking access to energy (70%) reside in just a handful of countries including Nigeria, where the rural population is the most affected. We observe here that Nigeria, who ranks 7th in world population, cannot provide access to electricity to an estimated 85 million people in both the urban and rural areas, which accounts for 42% of her population in 2013. It is also observed in table 1.3 below, that Sub-Saharan Africa accounts for the 10 least electrified countries in the world, even though the South Asian region has the highest number of population without access to electricity.

Table 1.3: Ten Least Electrified Countries in the World, 2011

Country	Population without access to electricity (%)
Malawi	93.0%
DR Congo	91.0%
Burkina Faso	87.0%
Madagascar	86.0%
Tanzania	85.0%
Uganda	85.0%
Kenya	81.0%
Mozambique	80.0%
Zambia	78.0%

Source: IEA, 2013

In order to tackle the challenge of energy security and access especially in the aforementioned afflicted regions, and specifically in Nigeria, successive governments have developed various energy policies and embarked on a range of measures (both successful and failed). Despite all efforts, rural access to electricity is estimated to be only 35% in Nigeria, while per capita consumption of electricity is 125kWh approximately (Oseni, 2012).

Table 1.4 below shows the percentage distribution of households by states and various sources of electricity supply in Nigeria in 2009. While the PHCN (NEPA) column heading represents electricity supply from the national grid, the IPP represents power from Independent Power Producers and Private Generators represents those that get electricity from stand-alone generating plants that use either diesel or petrol. Those that get electricity supply through rural electrification programmes are grouped under rural electrification in the table, while those that get from solar sources are grouped under Solar, and those that do not have any access at all to electricity supply are grouped under none.

We observe from the table that an average of 35.3%[2] of households lacked access to electricity that year. We also observe that rural electrification is yet to be taken seriously, as there is near absence of solar electricity in Nigeria in the survey year as well as the low rural electrification rate provided in the table.

The table also shows that almost 50% of the states in Nigeria have more than 50% of people without access to electricity as highlighted in Yellow below. This brings to the fore the challenge of lack of electricity access in various part of Nigeria.

[2] This value is much lower than the IEA value in table 1.2, same for the rural-urban shares. The discrepancy in values may be attributed to a number of factors such as sampling variability, incomplete coverage, reporting errors for individual units, non-response and imputations usually associated with surveys and data collection. However, the IEA data seems to be closer to the reality in Nigeria, and the idea is to provide a picture of the lack of electricity access situation in Nigeria, which can be deduced to be enormous from both sources (NBS and IEA).

Table 1.4: Percentage distribution of households by state and type of electricity supply, 2009

	Electricity Supply					Percent	
State	PHCN (NEPA) only	IPP/Rural Electrification only	Private Generator only	PHCN (NEPA) /Generator	IPP/Rural Electrification/Generator	Solar Panels	None
Abia	46.2	-	9.0	20.0	0.1	-	24.6
Adamawa	13.8	-	4.4	1.7	-	0.4	79.7
Akwa Ibom	38.2	0.8	10.2	6.2	0.6	-	44.1
Anambra	81.0	-	-	6.1	-	-	12.8
Bauchi	38.7	0.1	0.5	6.2	-	-	54.5
Bayelsa	6.6	25.7	13.2	0.6	23.8	0.3	29.8
Benue	16.0	19.5	1.7	0.7	-	-	62.0
Borno	17.3	-	3.3	0.4	-	-	79.0
Cross River	38.7	5.4	6.4	7.4	-	-	42.0
Delta	48.1	3.4	2.5	6.6	0.6	-	38.9
Ebonyi	35.0	-	2.9	1.4	-	-	60.7
Edo	84.8	1.1	0.8	6.2	-	-	7.0
Ekiti	77.9	-	-	4.1	-	-	18.0
Enugu	41.3	3.0	4.1	8.0	1.6	-	41.9
Gombe	35.9	-	0.4	0.8	-	0.5	62.4
Imo	69.0	-	1.8	17.7	1.0	0.3	10.1
Jigawa	32.0	-	-	0.1	-	-	67.9
Kaduna	43.4	1.1	3.8	2.7	0.3	0.3	48.4
Kano	43.8	-	1.8	3.2	0.5	-	50.6
Katsina	41.6	-	0.4	0.6	-	-	57.4
Kebbi	37.8	-	0.9	6.3	0.4	-	54.6
Kogi	54.8	-	3.4	2.4	3.2	0.2	35.9
Kwara	70.7	-	4.0	1.6	-	-	23.7
Lagos	54.3	0.2	1.3	36.2	1.9	-	6.1
Nasarawa	17.7	-	16.8	13.0	0.8	-	51.8
Niger	33.4	-	2.2	0.9	1.3	-	62.3
Ogun	71.6	-	0.9	10.6	-	-	16.8
Ondo	54.5	-	5.4	8.6	-	-	31.4
Osun	75.0	-	2.3	1.7	-	-	21.0
Oyo	46.1	-	10.1	18.2	-	-	25.6
Plateau	25.0	2.2	4.7	2.3	1.2	-	64.6
Rivers	24.2	13.0	13.4	19.4	0.9	-	29.2
Sokoto	19.3	0.5	0.6	13.6	0.3	-	65.7
Taraba	15.3	0.1	2.1	1.1	-	-	81.3
Yobe	24.3	0.9	0.1	0.9	-	-	73.7
Zamfara	35.6	-	-	-	-	-	64.4
FCT	33.3	-	5.2	22.1	1.0	-	38.4
Sector							
Urban	72.0	1.1	1.6	14.9	0.7	-	9.6
Rural	39.6	2.1	3.8	3.4	1.1	0.1	49.9
National	51.3	1.7	3.0	7.6	1.0	-	35.3

Source: NBS/CBN/NCC Social-Economic Survey on Nigeria, 2010.

Private generators are also seen to be playing an increasingly important role in the electricity supply mix of Nigeria especially for the rich. The number of private generators used to supplement Power Holding Company of Nigeria (PHCN) supply rose from 5.8% in 2007 to 7.6% in 2009.

Some states especially those in the oil-rich Niger-Delta region also have more private generators than others. This can be attributed to the availability of cheap locally refined diesel, and the difficult creek terrain, which makes grid connection challenging. This provides an opportunity for private investors to operate mini-grid/off-grid diesel-based generator systems for rural electrification in such states, and more of these opportunities for private investments need to be explored in other states as well.

It is also evident from the table that while the challenge of lack of electricity supply is prevalent across Nigeria, the Northern part of the country suffers more. The highest number of households without access to any form of electricity supply in 2009 was recorded in Taraba state (Northeast Nigeria) and put at 81.3%. Lagos state (Southwest Nigeria) on the other hand recorded the smallest percentage of households without access to electricity at 6.1%. Therefore, rural electrification programmes in the country need to be prioritized according to areas most affected. However, this is not the case currently in Nigeria due to a number of factors such as political interference and corruption. These issues are discussed in chapter five of this thesis.

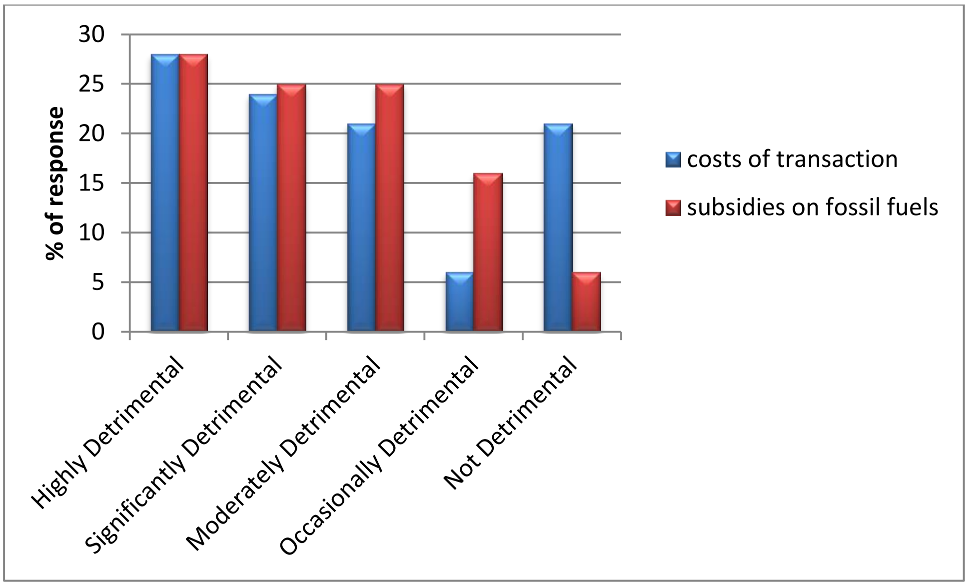
1.1.1 Constraints and Barriers to Energy Access in Nigeria

Some of the constraints and barriers hindering electricity access in Nigeria have been classified into four broad headings, as provided by ESMAP 2005. They include: Tariffs, Finance and investment risks, Policy Implementation, Governance/Business Environment, Local Capacity for Rural Electrification and rural entrepreneurship/income levels.

Until very recently, Nigeria's electricity sector has been wholly regulated and dominated by government monopoly, which made entry into the sector impossible. This led to an electricity pricing/tariff structure that was highly subsidized and did not reflect market forces. According to UNEP (2012), the major drivers of energy investments are profitability and competitiveness of other technologies. Thus, a critical barrier to expanding rural energy access in Nigeria is the unattractive and highly subsidized electricity tariff structure, which affects the inflow of finance into the sector.

ESMAP (2005) also suggests that the dearth of long-term loans, high domestic interest rates, political uncertainty, corruption and crime, inadequate customer information and mismanagement of government utility, policy inconsistency and lack of sustained reforms are some of the factors militating against the inflow of capital to the electricity sector of Nigeria.

Figure 1.1: View on costs of transaction and subsidies on fossil fuels



Source: UNEP (2012)

A UNEP (2012) survey of the experiences of financial institutions in financing renewable energy projects in developing countries, show that transaction costs and fossil fuel subsidies are major barriers to expanding rural energy access, this is depicted in figure 1.1 above.

The survey also shows that distortive electricity sector policies, policy inconsistencies, selective/non-implementation of policies and delayed passage of enabling sector bills all constitute governance barriers in expanding access to electricity in developing countries. Until 2005 when the Electricity Power Sector Reform ACT (EPSRA) was passed into law, there was no clear regulator in Nigeria's electricity sector, which created a significant barrier to private sector entry in all spheres of the chain of supply of the electricity sector of Nigeria.

In addition, the cost of doing business in Nigeria is unnecessarily high due to corruption, high crime rate, bureaucracy and lack of transparency. ESMAP (2005) views these as constraints to investments in the sector. Thus, an independent regulator; Nigerian Electricity Regulatory Commission (NERC) has to be effective and transparent in its dealings to avoid bureaucratic bottlenecks and unnecessary delays.

More so, the lack of local manufacturing capacity of important components of rural electrification projects does not only export jobs to other countries, but encourages bribery in the process of awarding contracts for importation of such components and delays rural electrification projects (ESMAP 2005). The market potential for rural electrification in Nigeria is enormous, thus, the present situation of lack of capacity in manufacturing constitutes a barrier for rural energy access. This is because, most companies involved in rural electrification only depend on contracts from government to import some components such as transformers, cables, insulators, conductors, etc., and are constrained by the yearly government budgets (ESMAP 2005).

Most rural communities in developing countries such as Nigeria are plagued with various forms of unemployment, lack of economic activities, inadequate income and lack of basic amenities. These factors, especially the fact that rural dwellers lack the required income to pay for energy services make rural communities unattractive for investments. Since the major motive of any investment is profitability, investors would rather plough their resources in markets with the most profit[3].

[3] See http://www.unglobalcompact.org/AboutTheGC/index.html (last visited on 19th of June 2012)

From the foregoing, it could be construed that the issue of mobilising finance, both private and government, is intrinsic, and constitutes the bedrock of every energy policy objective. Addressing this challenge is also determined by the amount of commitment from international organizations, regional and state governments, as well as the acknowledgement that the bleak projection of this challenge is undesirable

Therefore, in confronting the challenge of energy supply especially in the rural areas of Nigeria, novel ideas on financing, technologies, institutional framework, capacity building, as well as the capability of offering real accessibility to new sources of supply are essential. In this regard, the demand-side point of view should be taken into cognisance in terms of ensuring affordability as well as possibilities for innovation in the way of mobilising and financing energy supply[4].

Thus, as part of developing methods and tools for capacity building in rural electrification in Nigeria, it is an important first step to estimate the investment costs and investment need of rural electrification in the country. Thereafter, appropriate financing options for rural electrification are also needed to suggest ways Nigeria can be provided access to electricity in a sustainable fashion. The need to also meet the universal 'energy access for all' target of the IEA (2011) especially in Nigeria, and the investment challenge to achieve this target forms the basis for this doctoral research.

1.2 Justification of study

The choice of Nigeria as a case study for this research stems from the fact that it is the most populous country in Africa, and is currently ranked 2nd to India in terms of countries with the highest population without access to electricity in the world. Nigeria also lacks detailed research on investment requirements and financing issues/options of rural electrification.

[4] Monroy, C.R., and Hernandez, A.S., *Main Issues Concerning the Financing and Sustainability of Electrification Projects in Rural Areas: International Survey Results*, Energy for Sustainable development vol. 9, issue 2, pp. 17-25, June 2005

Literature review on financing rural electrification carried out in chapter three of this research shows that previous attempts at doing something related to this has been at a very preliminary level, and there is the lack of existing spatial electricity planning study that gives a detailed analysis of which mode of electricity supply (grid, mini-grid and off-grid) to be used in different parts of Nigeria.

The lack of any official Rural Electrification Strategy and Implementation Plan (RESIP) and Rural Electrification Master-plan (REM) for implementation on the part of the Nigerian government, which should have provided options for funding rural electrification in Nigeria, also contributes to the inspiration for this research.

Therefore, this research derives its justification from the need to fill the aforementioned gaps as it seeks to estimate the investment requirement needed for Nigeria to achieve universal electricity access by 2030. Thereafter, this research seeks to go further to identify the financing options suitable for rural electrification in Nigeria.

Moreover, being the first country-specific study in this area, outcomes of this PhD study is beneficial to other researchers, policy makers and planners. It provides an insight into the enormity of the challenge of rural electrification in Nigeria as well as lays a foundation for more research and innovations to be explored in this area. It also enriches the body of knowledge on electricity expansion planning, and forms a reference point for interested stakeholders.

According to the IEA World Energy Outlook 2011, which provides a lot of information on funding and estimated projected investment requirements by scenarios for different technology types, energy poverty (which was defined as the lack of access to modern energy services) is unacceptable and needs to be eradicated as quickly as possible. To this end, strong, co-ordinated and innovative actions are required on a global scale to achieve energy for all in 2030.

Above all, mobilizing investments and finances from all sources, most especially the private sector towards rural energy projects is crucial, and innovative research towards developing business models that are commercially-viable for rural energy projects should be galvanized. This underscores the choice of ***'financing'*** as the choice theme for this research.

The UN declared 2012 the "International Year of Sustainable Energy for All" as part of global efforts to raise awareness about the importance of increasing sustainable access to energy. This declaration provides more impetus to that given to energy access issues in the past, such as the Rio Summit of 1992 and Johannesburg Summit of 2002[5].

1.3 Research Questions

This research is therefore aimed at addressing the following research questions:

- What combination of Grid, Mini-grid and Off-grid electricity supply options should Nigeria adopt in providing universal electricity access to her diverse rural areas by 2030?

- What is the investment requirement towards achieving universal electrification in Nigeria by 2030?

- How can this investment be financed?

The first question is an important first step for this research as it provides us with the least cost electricity supply network options (grid, mini-grid and off-grid) that would best serve the rural areas of Nigeria, given their different energy resources, demography, energy demand and economic activities/income.

[5] S, Bhattacharyya (ed) 2013, Rural Electrification Through Decentralised Off-Grid Systems in Developing Countries. London: Springer. P. 3

Following the first question, the second question provides the ingredients of knowing what the challenge of rural electrification in Nigeria actually is, and translates it in terms of investment requirement towards achieving universal access to electricity for all Nigerians in 2030.

The third question addresses the issue of financing the required investments towards improving electricity access and achieving universal electrification in Nigeria by 2030.

1.4 Objectives of Study

The broad objective of this research is to estimate the investment requirements and financing options for rural electrification in Nigeria towards achieving universal electricity access by 2030. Specifically, this research will:

- Carefully analyse appropriate electricity supply modes (grid, mini-grid and off-grid) that Nigeria can adopt to provide universal electricity access to her diverse rural population in 2030

- Estimate the investment requirement towards achieving universal electricity access to all Nigerians in 2030

- Determine the appropriate financing options that could be adopted in Nigeria to achieve the 2030 'electricity for all' objective.

NOTE: (The words "carefully analyse" as used in objective number one above refers to choosing the electricity supply modes based on cost effectiveness).

1.5 Methodology

This study adopts the ***Network Planner Model*** developed by the Earth Institute of Columbia University, New York. This model was used by Kemausuor et al (2012) in an EU Energy Initiative – Partnership Dialogue

Facility (EUEI PDF) support study for increasing energy access services in Ghana. The same model was used by (Parshall, Pillai, Mohan, Sanoh, & Modi, 2009), but was called ***Spatial Electricity Planning Model and Costing*** in a similar study in Kenya.

For this study, the NP model was used to estimate the cost of increasing access to electricity in rural areas currently without electricity in Nigeria which in-turn provided a suitable basis for discussing financing options/strategies. The Model was relied upon to answer the first and second questions of this research.

On obtaining the total cost of electrification, being results gotten from the use of the NP model in Chapter Four of this thesis, the study went ahead to explore different options/models at community (LGA), State, Zonal, and national levels to finance the electrification of the rural areas of Nigeria, which answers the third question of this research.

One very fundamental aspect of the adopted model for this research is that it doesn't only estimate costs of off-grid technologies or grid systems alone, it estimates both and goes further to compare them, and identify the least cost technology suitable for various communities in Nigeria. This part of the model was very useful for the first and second questions of this PhD thesis. However, this model has some limitations which include: its current limitation to three technologies (grid, off-grid solar PV and Mini-grid diesel generator) only; and the lack of consideration for the constantly changing nature of costs brought about by economic and technological changes. The assumption that all cost conditions remain unchanged throughout the planning period is not obtainable in reality; Costs do not include the technical and geographical constraints of connecting communities, such as hilly terrains, flat-lands, major roads etc. This could increase total capital cost if taken into consideration; and the generation cost for grid technology is also not incorporated.

Notwithstanding the aforementioned limitations, the NP model was very useful as a preliminary means of assessing costs of different electrification scenarios for this study.

Details of the model description, application and results can all be found in Chapter Four of this thesis.

To answer the third question, a scenario approach and stakeholder interviews were carried out. The scenario approach entailed looking at current funding status of rural electrification in Nigeria under the business as usual case, to determine if this is sufficient to meet the targets of the government. Whereas, the Network Planner (NP) case presents an alternative funding scenario based on the results derived from the NP analysis in chapter four. Triangulation was also used in each case to establish validity.

1.6 Data Collection and Sources

This research relies largely on secondary data, supplemented by primary data via interviews conducted with stakeholders within the Nigerian electricity supply industry. Some of these sources include:

- the Nigerian Living Standard Survey (NLSS, 2004 and 2009)
- the Nigeria Household Expenditure Survey by Nigeria Bureau of Statistics (NBS)
- National Accounts and Annual Reports by the Central Bank and the NBS
- Nigerian Electricity Regulatory Commission (NERC)
- Power Holding Company of Nigeria (PHCN)
- Transmission Company of Nigeria (TCN)
- Generation Companies of Nigeria (Gencos)
- Distribution Company of Nigeria (Discos)
- Energy Commission of Nigeria (ECN)
- National Population Commission (NPC)
- Rural Electrification Agency (REA)

- States and Local Governments contacts

Table 1.5 below shows the data collection framework used as a guide for this PhD research:

Table 1.5: Data Requirements and Sources for Modelling Exercise

SN	DATA CATEGORY	DATA REQUIRED	SOURCE(S)
1	Low voltage Lines	Cost per meter or kilometre of lines Equipment costs (per connection) Equipment O&M cost Line lifetime Line O&M cost per year	Ministry of Energy, ECN, various distribution companies, PHCN
2	Grid Extension	Transformer Capacities Available (kW) Distribution loss Installation cost per connection Medium Voltage Line cost per meter Medium Voltage Line lifetime Medium Voltage Lines O&M costs per year Cost of transformers Transformer lifetime Transformer O&M costs	Ministry of Energy, PHCN, TCN, various distribution companies
3	Diesel Generator	Available System Capacities (kW) Diesel fuel (litres) consumed per kWh Diesel generator cost per kWh of energy produced Diesel generator installation cost (as fraction of generator cost) Diesel generator lifetime Diesel generator O&M cost per year (as fraction of generator cost Distribution Loss	Gencos, Mikano Generators: Other companies
4	Solar System	Available System Capacities (kW) PV balance (other accessories, excluding battery) cost as fraction of panel cost PV panel lifetime PV balance (other accessories, excluding battery) life time PV battery cost per kWh PV battery lifetime PV battery kWh per PV component kW PV component efficiency loss PV component O&M cost per year as fraction of component cost PV panel cost per PV component kilowatt	Ministry of Energy, ECN
5	Social, Economic and Finance metrics	Economic Growth Rate Population Growth Rates Electricity Demand Growth Elasticity of Electricity Demand Interest Rate	CBN, NBS, NPC
6	Electricity demand and/or consumption data (in KW and KWh)	Residential Social infrastructure (schools, health facilities, government offices, etc Commercial and industry Public uses (such as street lighting)	NBS, CBN, NERC, PHCN
7	Price/cost data for both Grid and off-grid (solar, diesel)	Materials for grid extension (poles, wire, transformers, etc.), and for off-grid (solar and diesel generation	ECN, NERC, various distribution companies

	technologies	equipment)	
		Recurring costs (operations & maintenance), and "soft costs" such as system design and installation	
		Electricity connection fees for households, businesses (single-phase and three-phase)	
8	Geo-spatial location data	Coordinates of Communities and locations of existing grid networks plus the population data for those communities	NBS, NERC, PHCN, NPC

As regards access to data, a formal letter requesting relevant data for this research was sent out to all the agencies listed above, and the response was overwhelmingly positive. Most data required for the modelling exercise was received, and others had to be purchased from vendors. The interviews/meetings were conducted face-to-face with all the relevant stakeholders interviewed, and they all voluntarily participated.

1.7 Scope and Limitation of the Study

The study covers the seven hundred and seventy four local government areas (774) and the thirty six (36) states of Nigeria, plus the Federal Capital Territory-Abuja. This is because the lack of electricity access affects every region in Nigeria (although it is worse in the Northern region); therefore, it was important to have a holistic picture of the sheer magnitude of this challenge from a broad perspective. The diverse geopolitical features of the different tiers of government in Nigeria, also makes it critical to have a national analysis. The modelling was carried out for Nigeria from 2013 to 2030 (17 years), with the aim of increasing electricity access to 100% in 2030.

Some of the limitations of this PhD research include the use of secondary data and assumptions in the analysis. This could however be overcome by carrying out community-specific techno-economic studies of the entire country. This too is beyond the scope of this PhD research considering the enormous resources and time required to embark on such survey in a huge country such as Nigeria, and the particular spate of insecurity currently plaguing the country, especially in the Northern part of the country where the energy access challenge is more pronounced.

It is also worthy to note at this juncture that the two previous studies on Kenya and Ghana mentioned above, where the spatial model and Network planner were used respectively were heavily funded and supported by different bodies such as the World Bank, the Gates foundation, the Earth institute and in the case of Ghana the EUEI PDF. Such resources are not available at an individual PhD level.

1.8 Structure of Thesis

This thesis is structured into six chapters in line with the research aims and objectives of the subject-matter. Following this introductory chapter is **Chapter Two**, which provides a background analysis for this research. It gives an insight into the status of the Nigerian Electricity Supply Industry (NESI) in terms of rural electrification/energy access issues, generation, transmission, distribution, and gives a historical overview of reforms till date within the industry.

Chapter Three reviews the relevant literatures as regards financing rural energy technologies/projects, financing sources/mechanisms, various technologies for rural electrification, and other relevant literatures on energy access.

Chapter Four provides the methodology, analytical framework, Network planner modelling and results of the modelling carried out in this research. The selection of the least-cost electrification modes (grid, mini-grid and off-grid) to be adopted for rural electrification in Nigeria, as well as the estimated costs/financial requirements for investing in such electrification mode in Nigeria was provided here. This answers the first and second research questions/objectives of this study.

Chapter Five addresses the third research question/objective of this thesis, which is to find sustainable financing options and models for rural electrification in Nigeria. This was arrived at through logical assumptions based on the analysis carried out in chapter four, an interview conducted to get feedbacks from stakeholders within and outside the Nigerian Electricity Supply Industry, a scenario analysis carried out, as well lessons from the experiences of other countries.

Chapter Six concludes this research and provides key findings and recommendations.

CHAPTER TWO
BACKGROUND ANALYSIS

2.1 An overview of socio-economic Conditions in Nigeria

2.1.1 General Information

The amalgamation of the Northern and Southern protectorates in 1914 by the British colonial administration gave birth to Nigeria as a nation-state (NPC, 2008). Nigeria gained independence from Britain in October 1960 and became a republic in October 1963 with different administrative structures. Following decades of political instability and military interventions, the country adopted a new constitution and returned to democratic system of government in 1999.

The country is presently grouped into six geo-political zones: North West, North East, North Central, South East, South-South and South-West, made up of 36 states and the Federal Capital Territory (FCT) Abuja, and 774 local government areas (LGAs). Thus, Nigeria runs a federal system with 3 tiers of government.

2.1.2 Economy

Nigeria is a mono-product economy, heavily dependent on oil. Though the nation is endowed with abundant natural resources spanning agriculture, mineral resources, oil, gas and tourism, crude oil export is the highest foreign exchange earner for the economy. With a maximum oil production of 2.5 million barrels per day, it is the largest producer of oil in Africa and 6th largest in the world[6]. Oil revenue accounts for 85% of government revenue, one-fifth of GDP and 90% of export earnings (FCO, 2011). GDP as at 2011 stood at US$237.9bn, with agriculture accounting for 40% of GDP, GDP per head US$ 1, 391 (CBN, 2013). Twelve million Children lack access to basic education, a fifth of Nigerian children die before the age of 5 and the

[6] See http://www.nnpcgroup.com/NNPCBusiness/UpstreamVentures/OilProduction.aspx (last visited on the 15th of April, 2013)

Transparency Corruption Perception Index ranked Nigeria 139th out of 176 most corrupt countries in 2012. Table 2.1 below shows some fundamental indexes of Nigeria.

Table 2.1: Basic Demographic Indicators in Nigeria from various sources

Current Population based on 2006 growth rate	171,888,510	2013
Population as at 2006 census:	140,431,790	2006
Population growth:	3.2 %	2006
GDP (current $):	237.9 billion	2011
GDP by sector : Agriculture 40%, Services 30%, Manufacturing 15%, Oil 14%.	2012 est.	
GDP growth (annual %) :	6.58	2012
Labour force:	53.83 million	2012 est.
Labour force by occupation: Agriculture 70%, Industry 10%, Services 20% (1999 est.)		
Population below poverty line:	46%	2010 est.
Distribution of family income (Gini Index):	43.7	2003
Inflation rate (%):	9.5	2013 (Feb.)
Interest rates in interbank money market	10.28%	2013(Mar.)
Lending rate	16.56%-24.60%	2013 (Feb.)
Exchange rate (dollar)	155.75	2013 (April)
Life expectancy (years):	52.05	2012 est.
Fertility rate (births per woman):	5.38	2012 est.
Infant mortality rate (per 1000 live births):	74.36	2012 est.
Under 5 mortality rate (per 1000 children):	157	2008
Literacy (age 15 & over can read and write) (%):	Male 72.1, Female 50.4,	2010 est.
Urban Population	50% of total population 2010	
Rate of urbanization	3.5%	2010-2015 est.

Source: World Bank homepage, CIA homepage, CBN, NPC and NBS

2.1.3 People

Nigeria has an estimated population of 171 million people in 2013, which makes it the largest country in Africa (NPC, 2013). Average population density going by the 2006 census was estimated at 150 people per square kilometre, with the most densely populated states being Lagos state in the South-West, and Kano state in the North-West. Most other densely populated states are found in the South-East. The nation is diverse with over 500 indigenous languages, 250 ethnic groups, and two major religions; Islam and Christianity. The major ethnic groups are Hausa-Fulani in the North, Igbo in the South-East and Yoruba in the South-West.

2.1.4 Geography and Climate

Nigeria is located in the West African sub-region between latitudes 4^{o} 16' and 13^{o} 53' North and longitudes 2^{o} 40' and 14^{o} 41' East. Nigeria is bordered by Niger, Chad, Cameroon and Benin to the North, North-West, East and West respectively (NDHS, 2008). Nigeria has a land area of 923,768 square kilometres and is bordered to the South by an approximately 850 kilometres of the Atlantic Ocean.

The country has a tropical climate with two seasons; wet and dry. The dry season occurs from October to March, with temperatures ranging between 25^{o}C to 40^{o}C and dusty harmattan wind in the North. The wet season occurs from April to September with rainfalls ranging from 2,650 millimetres in the South to less than 600 millimetres in parts of the North.

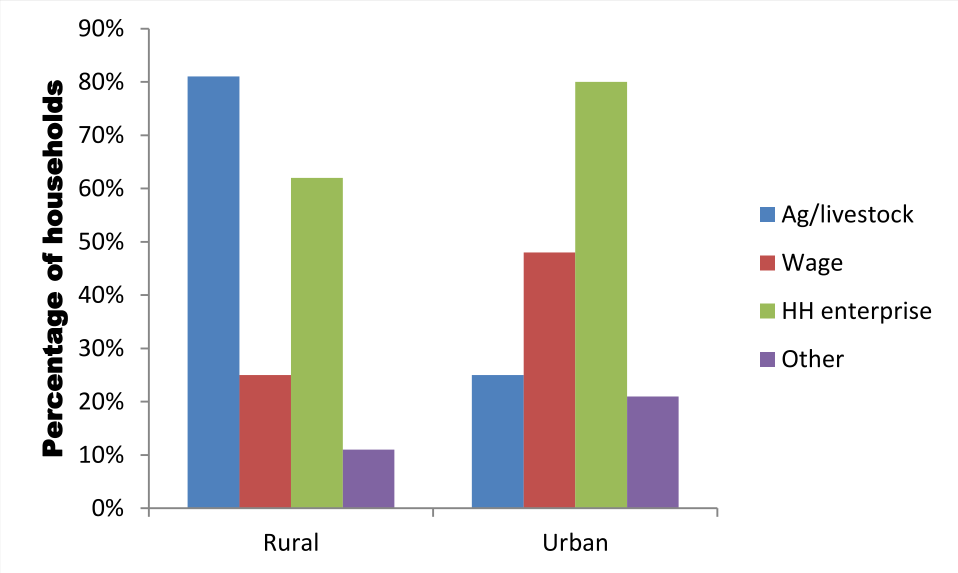
2.1.5 Rural and Urban area

According to the National demographic and health survey of Nigeria (NDHS) 2008, 100,284 million people lived in the rural areas while 49,915 million people lived in the urban areas in 2008. The 2008 National demographic and health survey (NDHS) also puts Nigeria's number of households at 34,070 million, with 12,100 million households in the urban areas and 21,970 million households in the rural areas. Average household size is 4.4 persons, with the urban household size being slightly lower at 4.1 persons, while the rural household size is 4.6

2.1.6 Other Household Information

The Annual Abstract of Statistics on Nigeria, 2010 (NBS, 2010) provides some salient household information. Major income sources in Nigeria are agriculture/livestock, wage/salary, enterprise and others. The major source of household income for the rural areas is agriculture while that of the urban area is household enterprise. Income sources for households in Nigeria are clearly diversified, with over 80% of households having at least two sources of income as shown in figure 2.1 below.

Figure 2.1: Income Sources for Nigerian Households, 2010

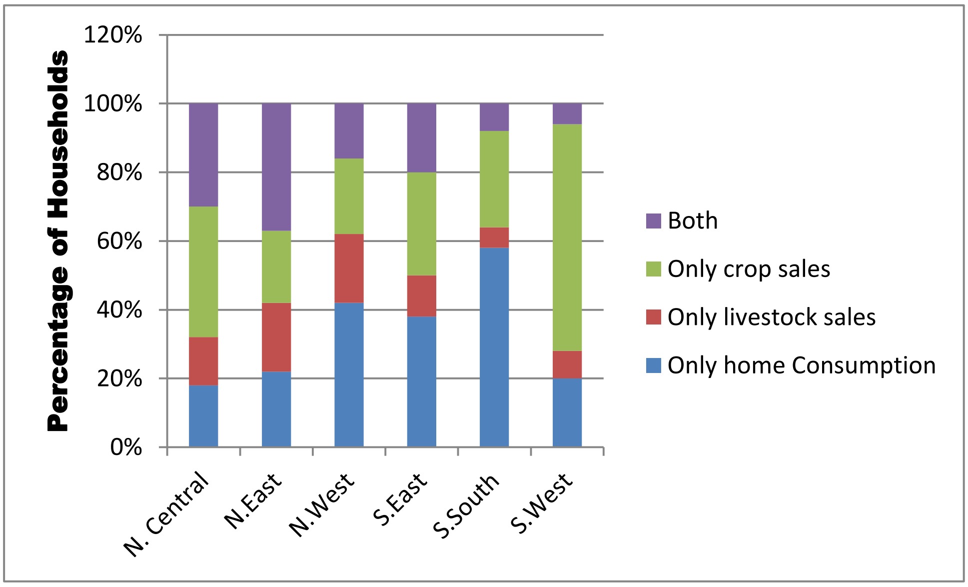


Source: National Bureau of Statistics (NBS) 2010

Data from the Annual Abstract of Statistics (2010) also shows that while about 60% of all the households in Nigeria are into farming (crops or livestock), not all of them do it for profit making. A third of these farmers are estimated to engage in farming for consumption, and do not earn any profit from crops or livestock sales.

The variation in the share of households that sell and/or consume their farm produce across the six geopolitical zones in Nigeria is shown in table 2.2 below. While the North-East and North-Central zones are likely to sell both crops and livestock produce, the South-South and South-West zones are least likely to do both. The South-South zone has the highest percentage of households that only engage in farming for home consumption only in the entire country.

Figure 2.2: Share in Percentage of Income Sources per Household in Nigeria

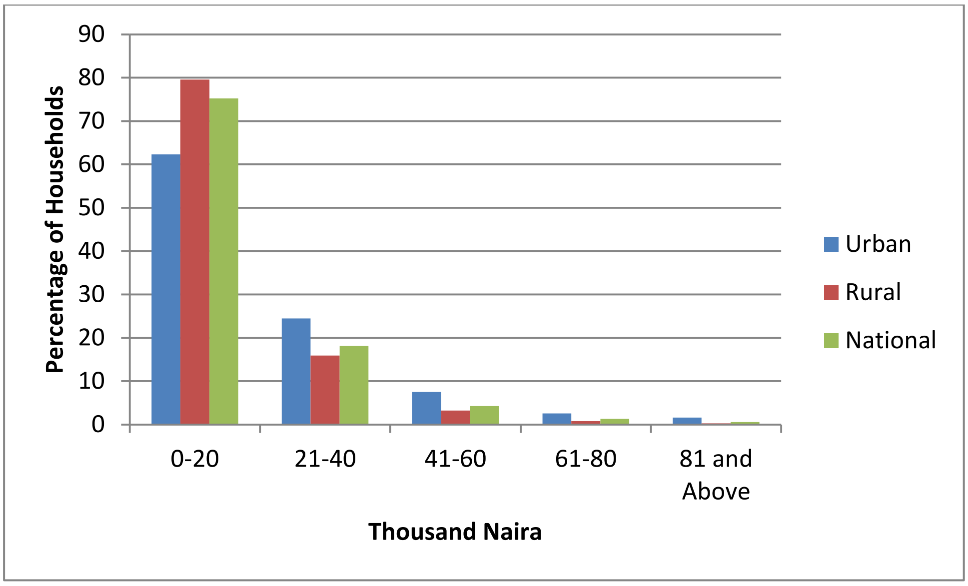


Source: National Bureau of Statistics (NBS) 2010

Income/allowances information from the NBS (2010) shows that 75.2% of households in 2008 earned between 1-20,000 naira[7], while an average of 24.4% earned between 21,000 naira and 40,000 naira, and only 0.2% earned above 81,000 naira. The income disparity is wide, with 98.7% of the rural population earning less than 60,000 naira per month, while 5.7% 0f the urban households earn between 61,000-600,000 naira monthly (see figure 2.3 below and complete table in appendix 4)

[7] As at 31/12/2008, 1 GBP was equal to 189 naira, and 1 dollar was equal to 130 naira. However, as at (12/04/2013), 1 GBP is equal to 239 naira, and 1 dollar is equal to 155 naira

Figure 2.3: Percentage Distribution of Households Monthly Income/Allowances, 2008



Source: National Bureau of Statistics (NBS) 2010

Data on percentage distribution of households in Nigeria by type of fuel for cooking for year 2007, 2008 and 2009, provided by NBS, is shown in the table 2.2 below. It is glaring that most households in Nigeria rely on wood as a cooking fuel especially in the rural areas, while most households in the urban areas rely on kerosene as their cooking fuel (See full table in Appendix 4).

Table 2.2: Percentage Distribution of Households by Type of Fuel for Cooking, 2007, 2008 & 2009 (Percent)

State Average	Electricity			Gas			Kerosene			Wood			Coal		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Urban	1.5	0.5	0.5	2	1.8	2	54.1	49.6	55.3	39	44.9	40.6	3.4	3.1	1.6
Rural	*0.3*	*0.1*	*0.3*	*0.1*	*0.1*	*0.3*	*7*	*7.3*	*11.9*	*92*	*92.1*	*87.1*	*0.6*	*0.4*	*0.3*
National	0.7	0.2	0.4	0.7	0.6	0.9	22.9	18.5	27.5	74.1	79.6	70.4	1.6	1.1	0.8

Source: National Bureau of Statistics (Nigeria)-Annual Abstract of Statistics (2010)

2.2 Electricity supply and demand

2.2.1 Current status of power generating infrastructure

As part of the electricity reforms embarked upon in 2005, government participation in the industry was restricted to transmission and regulation only, while generation and distribution functions were privatized. As at September 2013, the process of sale of Nigeria's power generating facilities to various companies had been completed; however, full take-over of the assets took effect in November, 2013.

The successor generation companies (Gencos) are six in number, with four being thermal and two being hydro. In addition, Nigeria has five Independent Power Producers (IPPs) already existing with many more being developed, as well as ten National Integrated Power Projects (NIPP) power plants at various stages of development[8]. The table 2.3 below shows Nigeria's existing and on-going generating facilities.

[8] USAID, Africa Infrastructure Program (AIP) Nigeria-Energy & Climate Change (E&CC) Program, being an NBET Workshop on Overview of Wholesale Power Sector & Privatization. Abuja: June 12, 2012.

Table 2.3: Data on Nigeria's generating facilities as at September 2013

Generation Company	**Location**	**Installed Capacity (MW)**	**Available Capacity (MW)**
GENCOS			
KAINJI	NORTH	760	100
JEBBA	NORTH	540	289
SHIRORO	NORTH	600	450
EGBIN	WEST	1320	660
SAPELE	WEST	1020	0
DELTA	WEST	900	140
AFAM IV-V	EAST	776	75
GEREGU	WEST	414	138
TOTAL		**6330**	**1852**
FGN OWNED PLANTS			
OMOTOSHO GAS	WEST	304	126
OLORUNSOGO GAS	WEST	304	210
TOTAL		**608**	**336**
LEGACY IPPS			
OKPAI	WEST	480	300
AFAM VI	EAST	650	650
A.E.S.	WEST	294	160
TOTAL		**1424**	**1110**
NDPHC|NIPP POWER PLANTS			
GEREGU NIPP	WEST	434	434
SAPELE NIPP	WEST	450	250
ALAOJI NIPP	EAST	960	0
OLORUNSOGO NIPP	WEST	675	500
OMOTOSHO NIPP	WEST	500	375
IHOVBOR NIPP	WEST	450	0
CALABAR NIPP	EAST	563	0
GBARAIN NIPP	WEST	225	0
EGBEMA NIPP	EAST	338	0
OMOKU NIPP	EAST	225	0
TOTAL		**4820**	**1559**
STATE GOVERNMENT POWER PLANTS			
IBOM POWER	EAST	190	0
OMOKU (RIVERS STATE)	EAST	150	0
TRANS AMADI (RIVERS STATE)	EAST	130	0
AFAM (RIVERS STATE)	EAST	360	160
ELEME (RIVERS STATE)	EAST	75	0
TOTAL		**905**	**160**
GRAND TOTAL		**14087**	**5017**

Source: Nigerian Bulk Electricity Trading Company PLC (NBET)

The Nigerian Bulk Electricity Company is also at various stages of Power Purchase Agreement (PPA) negotiations with private developers, and table 2.4 below shows the front-runner IPPs and their expected generation capacities after signing the PPAs.

Table 2.4: Expected Capacity generation in Nigeria as at March 2014

Generation Company	Location	Installed Capacity (MW)	Available Capacity (MW)	Projected Capacity (MW)
GREENFIELD IPP				
AZURA	WEST	0		450
MOBIL NIG.	EAST	0		500
CHEVRON	WEST	0		700
TOTAL	EAST	0		417
NOTORE	EAST	0	40	525
MABON	NORTH	0		40
JBS Wind power	NORTH	0		40
MBH POWER	WEST	0		300
SYMBION/SUPERTEK	WEST	0		100
PARAS ENERGY	WEST	40	40	96
GEOMETRIC POWER (ENERGY ONLY) I	EAST	140	140	
GEOMETRIC POWER II	EAST	0		460
CENTURY POWER	EAST	0		502
BRESSON A.S	WEST	0		90
IKOT ABASI POWER	EAST	0		250
ENCON	WEST	0		250
ZUMA ENERGY	WEST	0		386
ETHIOPE ENERGY	WEST	0		960
HUDSON	WEST	0		535
ESSAR POWER	EAST	0		660
YELLOWSTONE	WEST	0		350
SUB-TOTAL		**180**	**220**	**7611**

Source: Nigerian Bulk Electricity Trading Company PLC (NBET)

2.2.2 Current status of transmission facilities

As at January 2012, 5,650km and 6,687km length of 330kV and 132kV trunk transmission lines supplied electricity across Nigeria respectively[9]. The table 2.5 below shows Nigeria's transmission data as at January 2012.

[9] From data requested and sourced from the Energy Commission of Nigeria (ECN) office, Abuja in March 2013

Table 2.5: Nigeria's Transmission Data as at January 2012

s/no	Parameters	Quantity
1	Capacity 330/132kV (MVA)	7,044
2	Capacity 132/33kV (MVA)	9,852
3	Number of 330kV Substations	28
4	Number of 132kV Substations	119
5	Total Number of 330kV circuits	60
6	Total Number of 132kV circuits	153
7	Length of 330kV lines (km)	5,650
8	Length of 132kV (km)	6,687
9	National Control Centre	1
10	Supplementary National Control Centre	1
11	Regional Control Centres	2

Source: Energy Commission of Nigeria (ECN)

The Transmission Company of Nigeria (TCN) who is saddled with management responsibilities of the 330/132kV transmission infrastructure of Nigeria grapples with a weakening grid due to inadequate maintenance and funding. Nigeria's current grid system cannot take the entire available generating load due to the lack of/or slow expansion of the transmission network when compared with the rapid growth of generating facilities around the country.

The TCN has three (3) major departments; Transmission Service Provider (TSP), Market Operator (MO) and System Operator (SO). While the TSP owns the transmission network and are in charge of transporting the energy, the MO implements the market rules and other commercial arrangements, while the SO oversees dispatch and grid control[10].

2.2.3 Current status of electricity distribution facilities

The power distribution system of Nigeria supplies medium voltage electric power (33kV and 11kV) through aerial lines of three-phase/three lines to

[10] Bureau of Public Enterprises (BPE), Overview of the Nigerian Electricity Industry (Roles, Responsibilities, Structure, Expectation), being a presentation by BPE at the Nigeria Power Sector Investment Forum-Lagos, Dubai, London, New York and Johannesburg, at Abuja-Nigeria (February, 2011)

consumers across the country[11]. Nigeria's post-privatization electricity distribution facilities encompass eleven (11) distribution companies (discos) spread across the country. They are: Abuja disco, Benin disco, Eko disco, Enugu disco, Ibadan disco, Ikeja disco, Jos disco, Kaduna disco, Kano disco, Port Harcourt disco and Yola disco. Table 2.6 below depicts this:

Table 2.6: Data on Nigeria's Distribution Companies as at September 2013

Company	**Pop Density**	**Distribution (Annual Energy)**
Abuja	83/km^2	1802GWh
Benin	229/km^2	1855GWh
Eko	2483/km^2	1440GWh
Enugu	566/km^2	1920GWh
Ibadan	172/km^2	1989GWh
Ikeja	2483/km^2	2077GWh
Jos	107/km^2	714GWh
Kaduna	113/km^2	1233GWh
Kano	291/km^2	788GWh
Port Harcourt	283/km^2	1164GWh
Yola	56/km^2	265GWh

Source: NBET

2.3 Rural Electrification Experience

2.3.1 Status

Nigeria is blessed with abundant energy resources where electricity can be generated; from natural gas, coal, oil, renewable energies including hydro resources (Sambo A., 2008). However, most of these resources have not been efficiently harnessed to solve the energy crisis Nigeria is engulfed in, and relies to a large extent on just two energy resources – hydro and natural gas on a ratio 30:70 basis.

[11] *Supra* note 3

Though electricity was first produced in Lagos-Nigeria in 1869, demand for energy services especially electricity in the rural areas far outstrips supply. Fuel wood is the major source of cooking in most households and only about 40% of the country's population have access to the national grid, and per capita electricity consumption is 136 kWh (Sambo A., 2007). In fact, the poorest 40% have no access to energy services at all and electricity capacity is still as low as 40 watts per capita compared to China's 466 watts per capita (breakthrough institute, 2010).

Urban access to the grid system is 80%, while rural access is 20% (Iloeje, O.C. 2004). Although power generation was at its peak of 4,237 MW in August 2012[12], peak demand which has not been properly computed is projected to far outstrip supply by at least ratio 3:1[13]. Thus, there is a huge gap in electricity supply and demand in Nigeria, and the rural areas are the most affected.

In addition, due to the volatile nature of the Niger Delta region in Nigeria, there is incessant sabotage of pipelines, which make gas supply inadequate and cost of maintenance to rise. The country also loses approximately $13 billion annually due to electricity generator plants importation for independent generation. This is usually a standby alternative to electricity from the grid for those that can afford it. The downside here is the noise and environmental pollution that accompanies the use of these generators, which contributes greatly to global warming (breakthrough institute, 2010). Approximately 60 million people now use generators (captive power supply) in Nigeria and spend over 13 billion dollars fuelling and maintaining them annually[14].

[12] See http://www.punchng.com/business/business-economy/power-generation-hit-4237mw-on-monday-nnaji/ (last visited on the 24th of March, 2012).

[13] http://www.nigerianstat.gov.ng/sectorstat/sectors/Electricity%20Supply%20and%20Demand (last visited on the 24th of March, 2012).

[14] See http://www.energy.gov.ng/index.php?option=com_content&task=view&id=51&Itemid=58 (last visited on the 24th of March, 2012).

Nigeria's energy crisis is further compounded by the lack of enabling environment for private investors to embark on investments due to low and regulated prices, corruption, lack of transparency, inflation and high interest borrowing rates.

Electricity activities (generation, transmission and distribution) in Nigeria constitute a very small percentage of overall economic activities and accounts for less than 1% of the gross domestic product (GDP) but 54% of the share of utilities (electricity and water supply) in the GDP[15]. There is also the characteristic of inadequate capacity of electricity generation and inadequate supply inherent in the Nigerian power system. Peak demand is observed to be 1/3 of total installed generation capacity due to poor maintenance of power generating infrastructure and unavailability of spare parts. Table 2.7 shows the energy resources in Nigeria:

[15] National Bureau of Statistics, Nigeria at http://www.nigerianstat.gov.ng/index.php/pages/sectorStatistics (last visited on the 24th of March, 2012).

Table 2.7: Energy Resources in Nigeria (Conventional and Renewable as at October 2009)

<table>
<tr><th rowspan="2">S/no</th><th rowspan="2" colspan="2">Resource Type</th><th colspan="3">Reserves</th><th rowspan="2">Production</th><th rowspan="2">Domestic Utilization (Natural Units)</th></tr>
<tr><th colspan="2">Natural Units</th><th>Energy Units (Btoe*)</th></tr>
<tr><td>1</td><td colspan="2">Crude Oil</td><td colspan="2">36.22 billion barrels</td><td>5.03</td><td>2.5 million barrels/day</td><td>450,000 barrels/day</td></tr>
<tr><td>2</td><td colspan="2">Natural Gas</td><td colspan="2">187 Trillion SCF</td><td>4.19</td><td>6 billion SCF/day</td><td>3.4 billion SCF/day</td></tr>
<tr><td>3</td><td colspan="2">Coal and Lignite</td><td colspan="2">2.175 billion tonnes</td><td>1.52</td><td>(insignificant)</td><td>(insignificant)</td></tr>
<tr><td>4</td><td colspan="2">Tar Sands</td><td colspan="2">31 billion barrels of equivalent</td><td>4.31</td><td>-</td><td>-</td></tr>
<tr><td>5</td><td colspan="2">Nuclear Element</td><td colspan="2">Not yet quantified</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>6</td><td colspan="2">Hydropower (large)</td><td colspan="2">11, 250MW</td><td>0.8 (over 38 years)</td><td>1938 MW</td><td>1938 MW</td></tr>
<tr><td>7</td><td colspan="2">Hydropower (small)</td><td colspan="2">3,500MW</td><td>0.34 (over 38 years)</td><td>30MW</td><td>30 MW</td></tr>
<tr><td>8</td><td colspan="2">Solar Radiation</td><td colspan="2">3.5-7.0 KWh/m^2/day (4.2 million MWh/day using 0.1% Nigerian land area)</td><td>5.2 (40 years and 0.1% Nigerian land area)</td><td>6 MWh/day Solar PV</td><td>6 MWh/day Solar PV</td></tr>
<tr><td>9</td><td colspan="2">Wind</td><td colspan="2">(2-4) m/s at 10m height (main land)</td><td>0.0003 (4m/s @ 12% speed probability, 70m height, 20m rootor, 0.1% land area, 40 yrs.)</td><td>-</td><td>-</td></tr>
<tr><td rowspan="3">10</td><td rowspan="3">Biomass</td><td>Fuel wood</td><td>11 million hectares of forest and woodland</td><td rowspan="3">Excess of 1.2tonnes/day</td><td>-</td><td>0.120 million tonnes/day</td><td>0.120 million tonnes/day</td></tr>
<tr><td>Animal Waste</td><td>211 million assorted animals</td><td>-</td><td>0.781 million tonnes of waste/day</td><td>Not available</td></tr>
<tr><td>Energy drops and Agricultural residue</td><td>29.2 million hectares of Arable Land (30% of total land)</td><td>-</td><td>0.256 million tonnes of assorted crops/day</td><td>Not available</td></tr>
</table>

Source: Sambo, A.S. (2009), The Place of Renewable Energy in The Nigerian Energy Sector, Presented at the World Future Council Workshop on Renewable Energy Policies, Addis Ababa, Ethiopia.

The NBS also provides information on households' electricity facilities, type of lighting fuels, electricity supply technologies and cooking fuel types. Table

2.8 shows the percentage distribution of households by the type of electricity facilities they have from 2005 to 2009. It is observed here that most households rely on public electricity facilities and other means, while only a few can afford to generate their own private electricity facilities.

Table 2.8: Percentage Distribution of Households by Type of Electricity Facilities, 2005-2009

Percent

Type of Electricity	2005	2006	2007	2008	2009
Public Only	43.6	39.6	47.3	41.3	51.3
Public/Private	4.3	2.15	5.8	7.4	7.6
Private Only	3.4	1.8	2.7	3.2	3.0
Others	48.7	56.6	44.2	48.0	38.1
Total	100.0	100.0	100.0	100.0	100.0

Source: National Bureau of Statistics - General Households Survey

The 2010/2011 General Housing Survey carried out by the National Bureau of Statistics in Nigeria, provides data on the population distribution of regular households by type of main lighting fuels. Table 2.9 below shows that more households rely on kerosene as the main lighting fuel, followed by electricity, battery/dry cell and firewood respectively.

Table 2.9: Population Distribution of Regular Households by Type of Main Lighting Fuel – National, 2010 (Percent)

Regions	**Collected firewood**	**Purchased firewood**	**Grass**	**Kerosene**	**Electricity**	**Gas**	**Battery/Dry Cell**	**Candles**	**Other**
North -Central	9.7	1.4	0.2	33.7	31.1	0.1	17.0	0.3	6.5
North -East	11.3	4.8	0.4	21.8	21.3	0.1	36.3	0.3	3.6
North -West	13.2	8.0	0.7	28.6	17.0	0.0	27.8	1.8	2.9
South -East	6.0	1.3	0.7	48.3	41.2	0.3	0.0	0.1	2.2
South-South	2.7	0.9	1.3	36.5	52.4	0.2	1.9	0.9	3.3
South -West	0.7	0.2	0.2	50.4	42.7	0.1	4.0	0.4	1.1
Urban	2.6	1.5	0.4	32.8	57.2	0.2	3.6	0.4	1.2
Rural	9.5	3.6	0.7	41.3	20.0	0.1	19.6	0.9	4.2
NGA	6.8	2.8	0.6	38.0	34.7	0.1	13.3	0.7	3.0

Source: National Bureau of Statistics - General Household Survey Panel 2010/2011

Table 2.10 below shows the source of electricity supply by geopolitical zones in Nigeria, 2010/2011. We observe that an average of 85.5% of households currently having access to electricity derive their source of electricity from the grid. Only 3.4% of households sampled acquire electricity through rural electrification, and 2.5% from private generators.

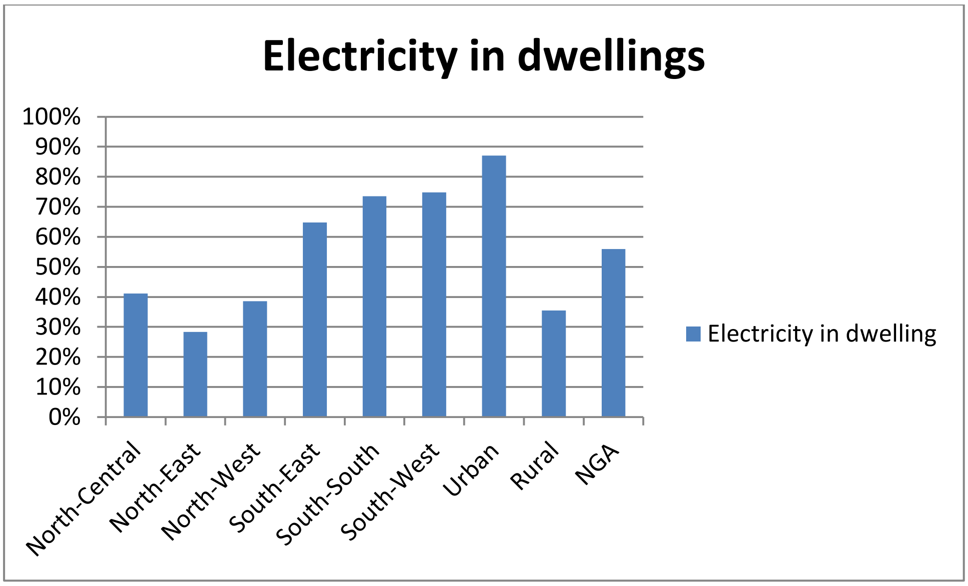
Table 2.10: Percentage Distribution of Household by Type of Electricity Supply, 2010 (Percent)

Regions	PHCN	Rural Electrification	Private Generator	PHCN (NEPA)/ Generator	Rural Electricity / Generator	Solar Panel
North-Central	81.9	1.8	1.0	14.9	0.0	0.5
North-East	82.3	9.8	1.6	5.9	0.5	0.0
North-West	94.8	2.3	0.9	2.1	0.0	0.0
South-East	90.8	2.8	0.9	3.5	0.4	1.6
South-South	79.3	8.8	1.7	8.3	1.9	0.0
South-West	83.9	0.3	5.2	10.5	0.1	0.0
Urban	**86.1**	**1.0**	**3.1**	**9.3**	**0.4**	**0.2**
Rural	**84.5**	**7.2**	**1.6**	**5.5**	**0.7**	**0.5**
NGA	**85.5**	**3.4**	**2.5**	**7.8**	**0.5**	**0.3**

Source: National Bureau of Statistics - General Household Survey Panel 2010/2011

Given the erratic supply of electricity in Nigeria, Figure 2.4 and 2.5 provides information on electricity access in dwellings and the number of hours households in different geopolitical zones in Nigeria have electricity supply respectively. It is observed that 55% of households have electricity supply for an average of 35 hours per week. Figure 2.6 below also shows that the mean cost of this supply is N23, 696 Naira ($145).

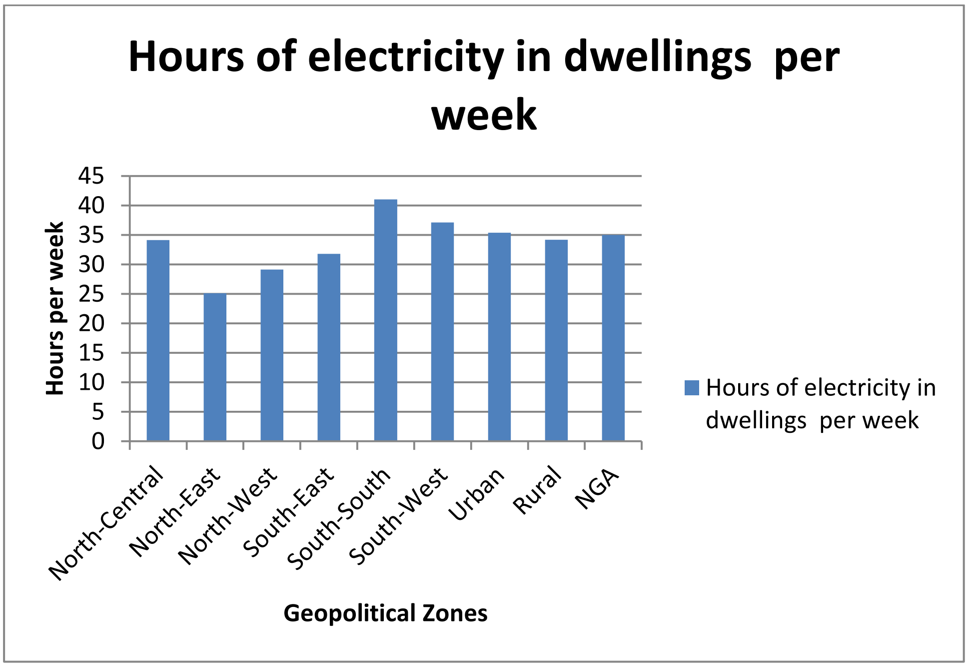
Figure 2.4: Electricity Access in Dwellings, 2010



Source: National Bureau of Statistics - General Household Survey Panel 2010/2011

While the urban areas get more supply of electricity as expected, it is put at 87.1% in Figure 2.4, and 35.5% of electricity is supplied to the rural areas. It is also observed that households in the southern part of the country have more electricity access and hours of availability compared to the North as shown in figure 2.5 below.

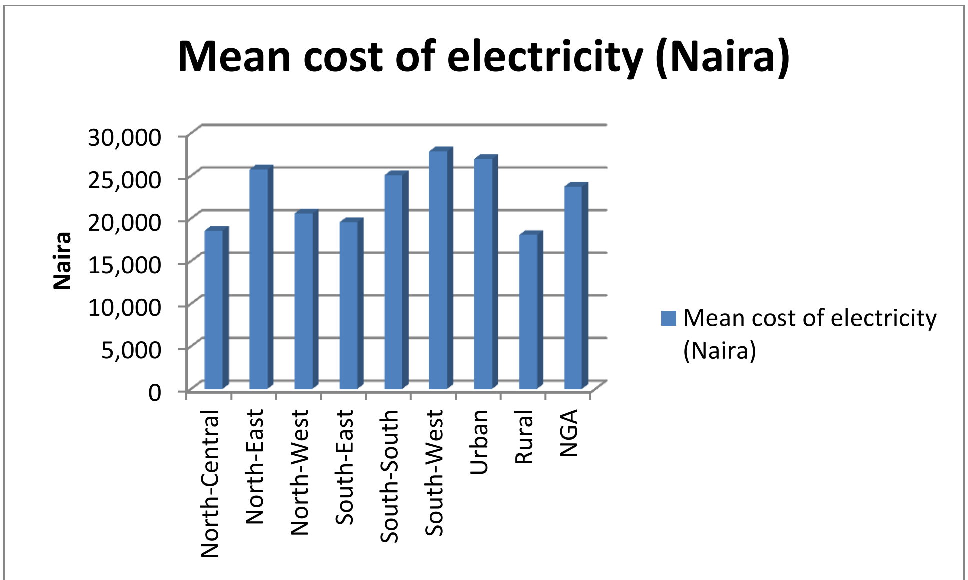
Figure 2.5: Rate of Electricity Availability in Nigeria, 2010



Source: National Bureau of Statistics - General Household Survey Panel 2010/2011

While Figure 2.6 below shows that the Southern parts incur more costs compared to the Northern zone, electricity supply in the urban areas is also shown to be N8000 ($49) more expensive than the rural areas on the average.

Figure 2.6: Mean Electricity Cost to Consumers per Week in Nigeria[16]

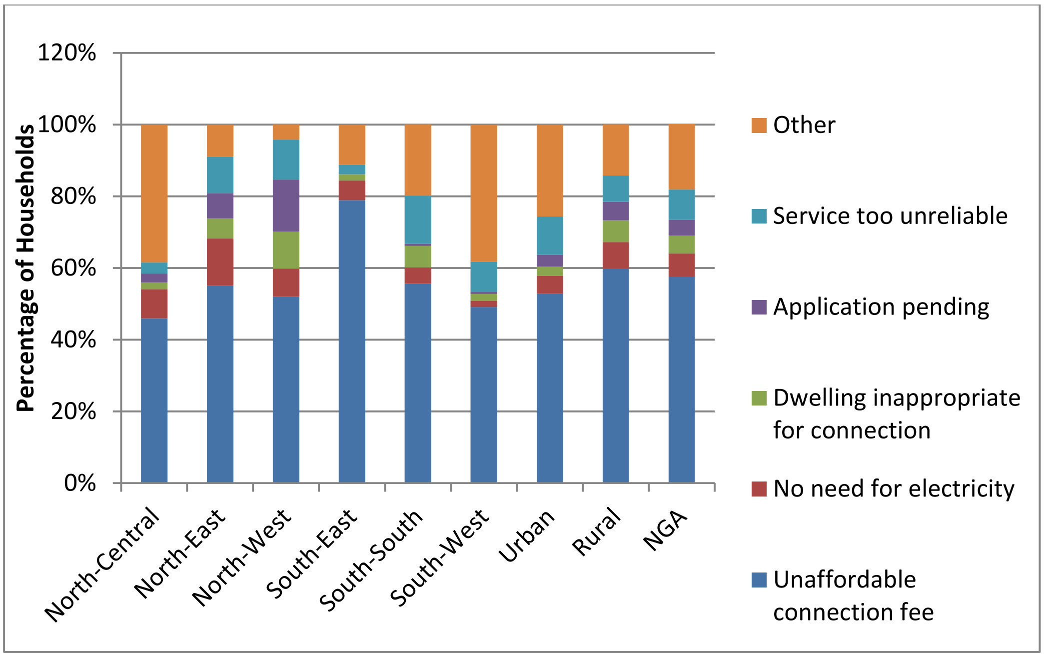


Source: National Bureau of Statistics - General Household Survey Panel 2010/2011

[16] Variations in costs here is due to the rate of availability and supply by various DisCos, as well as the categorization of consumers into residential, commercial and Industrial by NERC. See appendix 4 tables 8 and 9 for more details.

Figure 2.7 reports reasons for lack of electricity access and frequent blackouts in Nigeria based on the General Household Survey of 2010/2011. Over 60% of rural households sampled during the survey attributed the reason for lack of electricity access to frequent blackouts and high connection cost. Unreliability of service was also reported as one of the reasons for lack of electricity in Nigeria.

Figure 2.7: Why no access to Electricity?



Source: National Bureau of Statistics - General Household Survey Panel 2010/2011

However, in 2012, as a way of reducing the burden of high connection costs on consumers, the NERC abolished connection costs. Rather, the consumers would purchase the materials needed for connection to the grid, and invite the local DisCo for grid connection at no cost[17].

2.3.2 Process

In reviewing the process of rural electrification in Nigeria, this chapter looks at two distinctive phases: the evolution/pre-reform era (1914-2005) and the Reform/Current Era (2005 till date). These phases are discussed below.

2.3.2.1 Evolution/Pre-reform era (1914-2005)

Rural electrification during this era started in 1981, with the introduction of the National Rural Electrification Program (NREP). The aim was to connect

[17] See http://www.nercng.org/index.php/media-and-publicity/press-releases/121-connection-fees-prohibited-for-new-electricity-customers (last visited on the 22nd of April, 2014)

the headquarters of all the 774 Local Government Areas (LGAs) to the national grid (ESMAP 2005). This program was under the management of the Ministry of power and steel, and implemented by NEPA. According to ESMAP (2005) the program succeeded in connecting 600 of the LGAs to the national grid.

However, local network distribution within the connected LGAs has not progressed beyond the headquarters and its immediate environs, to other villages and rural communities due to unavailable government funding. In fact, at present, fewer rural households have access to electricity than when the NREP was initiated. This is due to the increase in electricity demand brought about by population increase and more houses being built without commensurate increase and expansion in rural electrification and new connections.

During this phase, Nigeria's power sector was completely monopolised by government owned NEPA, which controlled generation, transmission and distribution activities, up until 1998 when an amendment removed such monopoly[18]. This kick-started the reform process of the power sector, which eventually came to light in 2005. This period, especially the twenty years preceding 1999, witnessed a lack of considerable investments in power infrastructure and rural electrification. There was also lack of maintenance of existing power plants, thereby, bringing the sector to an appalling state, where generation dropped to 1,750MW from an installed capacity of 5,600MW, in comparison with a load demand of 6,000MW[19].

Therefore, rural electrification was not given priority during this phase, as attention was focused on electrifying major cities and state capitals, as well as local government headquarters only. Several structural constraints and lack of funding from government as discussed above also hindered the progress of rural electrification during this era.

[18] Ibid note 17

[19] Sambo, A.S. Matching Electricity Supply with Demand in Nigeria. IAEA publication Fourth Quarter 2008 at www.iaee.org/en/publications/newsletterdl.aspx?id=56 (last visited on the 8th of May, 2012).

The supply driven nature of rural electrification during this phase, as well as the political considerations rather than economic and social ones led to corruption and inflation of costs of doing rural electrification projects, with little value addition. The monopoly of the sector by NEPA and provision of funds by government alone did not help the drive for rural electrification. More so, relying on only the national grid system without diversifying the energy-mix for electricity generation to include other technologies such as off-grid systems, Mini-grid, stand-alone systems and renewables, slowed down rural electrification in Nigeria during this era (ESMAP 2005).

2.3.2.2 Reform/Current era (2005 till date)

In recognition of the need to double its efforts and drive for rural electrification in Nigeria, the Federal Government of Nigeria (FGN) in March 2005, enacted the Electric Power Sector Reform Act (EPSRA) of the country, which marked the beginning of the nation's ambitious drive to overhaul the power sector and position it to be more effective and efficient.

In terms of its approach and commitment to rural electrification, the FGN has charted its objectives in a number of documents including the EPSRA 2005, National Energy Policy 2001, and the Rural Electrification Policy (REP) 2009.

In the REP (2009), the FGN embraces the following guiding doctrines as the bedrock for its rural electrification drive:

i. Facilitate the provision of steady and reliable electric power at all times, at economic rates, for residential, commercial, industrial, and social activities in the country.

ii. Facilitate the extension of electricity services to all Nigerians, irrespective of where they live and work.

iii. Facilitate the promotion of private sector participation in Rural Electrification (on- and off-grid) in the development of the nation's abundant renewable energy resources by creating an enabling environment, while ensuring that governmental agencies, cooperatives and communities, where feasible, have adequate room to participate in enhanced electricity service delivery.

The FGN has also set a target of making reliable electricity available to 75% of the population (rural and urban) by 2020. The draft Rural Electrification Strategy and Implementation Plan (RESIP) which ought to have been produced not more than one year after the EPSRA of 2005, is still being reviewed as at April 2014, and is expected to be made official before the end of 2014.

Under the EPSRA 2005, investment in rural electrification is not under the purview of only the FGN anymore. The REA under section 88(13) of the EPSRA 2005 is mandated to use the Rural Electrification Fund (REF) to support and promote rural electrification programmes via participation from the private and public sectors. This marks a significant departure from the pre-reform era, where only the FGN was responsible for rural electrification. The REA in this phase of the rural electrification experience in Nigeria can now collaborate and cooperate with businesses, state and local governments, communities, multilateral/bilateral agencies and other stakeholders, to increase access to electricity in rural areas.

The EPSRA 2005 which created the REA and REF also mandated the REA to carry out new rural electrification projects as well as complete all rural electrification projects initiated by the FMPS through the NREP. However, the REA intends to implement various types of projects under three broad features of: Grid Extension, Mini-Grids, and Stand-alone systems.

The Rural Electrification Agency (REA) which was hitherto suspended by government in 2009 for corruption and contracts disputes was overhauled in 2012, with a new management team to drive the rural electrification objectives of the Federal Government. An eleven man supervisory board of the REA was also inaugurated in September 2013, with an injection of 16 billion naira for on-going and new rural electrification projects[20]. This, no doubt, is an important milestone and boost towards rural electrification in Nigeria, even though a lot more needs to be done to provide access to all the rural communities currently without access in Nigeria.

The FGN also inaugurated a pilot project tagged: 'Operation Light up Rural Nigeria' on the 4th of January, 2014. This, project which was commissioned by President Goodluck Jonathan, would deploy decentralised, off-grid technologies such as solar and wind to generate clean energy (less than 1MW) for some LGAs and select communities of 16 states[21]. The 'Operation Light Up Rural Nigeria' as a pilot project under the Ministry of Power has commissioned a solar village in the sub-urban area of Abuja since January 2014, is currently funded by the Ministry is Power, and it is envisaged that the private sector will buy-into the project in due course.

2.3.2.3 Electricity Power Sector Reform Act (EPSRA) 2005

The process culminating into the EPSRA started with the demonopolization of NEPA in 1998 and the coming on board of some Independent Power Producers (IPPs). Consequently, in 1999, the Electric power Sector Reform Committee (EPSRC) was set up by the National Council on Privatisation (NCP) to amongst other objectives, draft an enabling bill that would set the tone for a more robust, liberal, competitive and private sector-led growth for the Nigerian electricity sector (Ighodalo, A. 2006). In 2001, the draft version of the Electricity Power Sector Reform Bill was issued by the NCP, which later metamorphosed into the Act that was passed in 2005.

The EPSRA 2005 has the following key objectives: promote competition in the electricity industry of Nigeria, unbundle NEPA and provide the enabling environment for private investments to flow into the industry[22]. To achieve

[20] See http://www.thisdaylive.com/articles/fg-sets-aside-n16bn-for-electrification-of-rural-communities/158238/ (last visited on the 23rd of September, 2013)
[21] See http://www.ngrguardiannews.com/index.php/news/national-news/142459-fg-kicks-off-operation-light-up-rural-nigeria-tomorrow (last visited on the 7th of January, 2014)
[22] Federal Republic of Nigeria, Official Gazette EPSRA 2005

these objectives, the EPSRA 2005 provided for a vertical split-up of NEPA into various business units, such that there would be six generation companies (Gencos), eleven distribution companies (Discos) and one transmission company (TCN). A financial management unit is also to be established to take care of stranded costs and debts from the defunct NEPA (Sanyaolu, H.A. 2008).

To oversee the industry and ensure international best practices, a regulatory agency called NERC was established in 2005. The Rural Electrification Agency (REA) was also established along-side the enactment of the EPRSA 2005, to ensure increased rural electricity access to the most affected rural areas of Nigeria. Major stakeholders and agencies of this reform process include: the Power Holding Company of Nigeria (PHCN) now defunct, Nigerian Electricity Regulatory Commission (NERC), Ministry of Energy (MOE), Bureau of Public Enterprise (BPE), Electric Power Implementation Committee (EPIC), National Council on Privatization (NCP), and the Federal government of Nigeria (FGN).

The National Power Training Institute of Nigeria (NAPTIN) was established to amongst other things, cater for the manpower training needs of the power industry in Nigeria[23], as well as the Nigerian Bulk Electricity Trading Plc. (NBET), and Operator of the Nigerian Electricity Market (ONEM). In January 2012, the former Minister of Power Professor Barth Nnaji announced the winding down of activities in the corporate headquarters of the PHCN, signalling its liquidation. PHCN workers were redeployed to various successor companies[24].

At the moment, the power situation in Nigeria has not improved significantly compared to the previous era, as only about 3,600 MW of electricity is still actually generated[25]. However, the Federal government via its roadmap for

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[23] See http://www.naptin.org.ng/index.php/about-us/background/ (last visited on the 9th of May, 2012)
[24] See http://www.thisdaylive.com/articles/electricity-workers-threaten-strike-over-phcn-liquidation/107755/ (last visited on the 9th of May, 2012)
[25] See http://www.nigeriapowerreform.org/index.php/power-supply (last visited on the 11th of May, 2012)

power sector reform (2010), pledged the political will to implement the EPSR Act 2005, and enumerated specified immediate measures to achieve this goal, these include: removing barriers to private sector investment in the power industry, reforming the fuel-to-power sector and illuminating government's approach on the divestiture of the PHCN successor companies[26].

The Nigerian Government seem to have begun the implementation of the EPSRA 2005, albeit slowly. The important first steps of creating and unbundling the PHCN, and its eventual winding down in January 2012, shows that government is beginning to pay attention to the sector. The NERC has also announced a new cost reflective tariff to take effect from 1st of June 2012, in line with the Multi-Year-Tariff-Order (MYTO). The president of Nigeria also gave his total support and commitment to this planned increase, and asked the NERC to do more advocacy and enlightenment about this plan, during a one-day workshop on: Dismantling Barriers to Achieving Our Power Sector Vision", held at the presidential villa[27].

With these efforts, it is expected that the necessary grounds for the privatization and commercialization of Nigeria's power sector are being laid. Various Licenses have also been given to different private companies to build power plants under the reform programme, and the Federal Government (FG) also, recently signed a power agreement with France and Japan[28] aimed at building new power sub-stations and transmission lines in Nigeria. The president of Nigeria in January 2014 also charged the DisCos

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[26] Roadmap to power sector reform in Nigeria (2010), see http://www.nigeriaelectricityprivatisation.com/wp-content/uploads/downloads/2011/03/Roadmap-for-Power-Sector-Reform-Full-Version.pdf (last visited on the 11th of May, 2012)

[27] See http://www.thenigeriandaily.com/2012/05/07/jonathan-to-bpe-don%E2%80%99t-honour-requests-even-from-my-mother/ and http://www.vanguardngr.com/2012/03/fg-hikes-electricity-tariff-by-11/ (last visited on the 23rd of September, 2013)

[28] See http://www.leadership.ng/nga/articles/24822/2012/05/16/fg_signs_n334bn_power_agreement_france_japan.html (last visited on the 23rd of September, 2013)

and GenCos to work hard and provide significant improvement in power by June 2014[29].

Table 2.11 below summarizes the electricity sector milestones in Nigeria from 1896 till date.

Table 2.11: Nigeria's Electricity Sector Policy Milestones, 1896 till date

1896	Electricity was first generated in Lagos-Nigeria
1929	First electric utility company NESCO started operation with the construction of a hydro station at Kura, Jos-Nigeria.
1951	Electricity Corporation of Nigeria (ECN) was created to control coal and diesel plants
1956	4 units of coal powered station was commissioned in Oji, Enugu-Nigeria
1962	Establishment of the Niger Dams Authority (NDA) to manage the nation's water resources in the wake of increasing rural-urban drift First 132 KV line was constructed between Lagos and Ibadan-Nigeria.
1972	ECN and NDA were amalgamated to form the National Electric Power Authority (NEPA), which was saddled with the responsibilities of electricity generation, transmission, distribution and marketing to the final consumers, and was wholly owned and funded by the federal government.
1968-1990	Between 1968 and 1990, four major power stations were established and operated in Nigeria, they include: Ijora, Afam, Delta and Kainji Hydro Power Stations, serving an estimated 2 million consumers across the nation.
1998	By 1998 when some IPPs came on board, NEPA's exclusive monopoly of generation, transmission, distribution and marketing was whittled down.
2004	As at 2004, though NEPA had an installed capacity of 5,906 MW, but was only able to generate 3,400MW, even with generations from the 1PPs. This was due largely to lack of maintenance and competition as well as neglect by the government over the years. This gave rise to reforms.
2000	A committee set up by the government (Electric Power Implementation Committee EPIC) advocated for total privatisation and liberalisation when it submitted a report to the National Council on Privatisation (NCP).
2001	National Electric Power Policy (NEPP) was born as a result of the recommendations of EPIC
2005	• The Electric Power Sector Reform Act (EPSRA) was enacted, which provided for amongst other things, the unbundling of NEPA and restructuring the electricity sector to become more competitive, liberal and market driven. • Nigerian Electricity Regulatory Commission (NERC) was established • Rural Electrification Agency (REA) was also established. • NEPA was unbundled into Business Units (6 generating companies, 1 transmission company and 11 distribution companies) and Power Holding Company of Nigeria (PHCN) was also established.
2009	National Power Training Institute of Nigeria (NAPTIN) was created to act as official trainer of power sector personnel. Rural Electrification Policy (REP) was approved
2010	Roadmap for Power Sector Reform was launched by President Good-luck Jonathan
2012	PHCN was Liquidated and FGN relinquished 70% of its share of generation and distribution to various private companies and state governments.
2013	Handover of successor GenCos and DisCos to new private owners

[29] This Deadline was announced through the Minister of Power (Professor Chinedu Nebo) on the 7th of January 2014, during the inauguration of the board of the TCN in Abuja. It was all over the print and electronic media.

2.3.3 Technology Options for rural electrification in Nigeria

According to the draft Rural Electrification Strategy and Implementation Plan (RESIP 2012), technology options to be adopted for rural electrification in Nigeria are categorized into three: Grid extensions, Mini-grids, and Stand-alone systems. Therefore, the REA would take into consideration factors such as distance from existing distribution lines, load density, topography, potential for viable activity and prospect of electricity tariff collection, towards optimally combining her grid and off-grid electrification for the purpose of rural electrification in Nigeria.

2.3.3.1 Grid Electrification

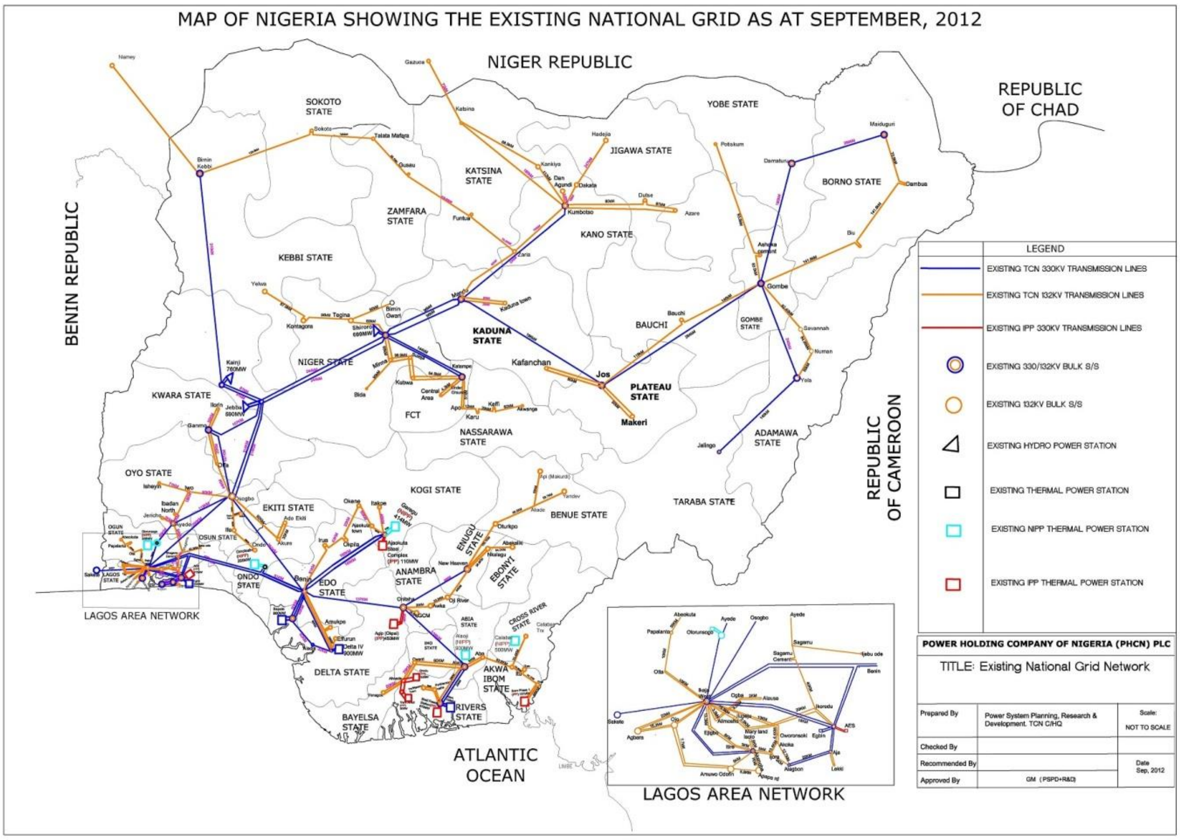
Grid extension is considered the first option for rural electrification based on the draft RESIP, except where mini-grids and stand-alone systems are relatively cheaper options to use. This preference stems from the fact that grid extension is considered to be more reliable, economical if load density is adequate, of better quality, has a high capacity for functional equipment, and is considered a critical factor for industrial development. However, this option will only be feasible where grid network already exists or near a site of a new proposed rural electrification project.

The draft RESIP encourages grid extensions among distribution companies who are favourably disposed to bid for rural electrification concessions. Community-based enterprises such as local cooperatives, NGOs, Local Government and other private businesses will be encouraged to run their own retail service supplying power from the grid, and the distribution companies will be required to provide non-discriminatory access to the existing grid network for these enterprises. REA will also collaborate with NERC to establish regulations for extending the grid to rural consumers.

NERC allows for between 1MW to 20MW of power to be generated as embedded power generation within the distribution zones under NERC regulation, while REA is allowed to regulate less than 1MW electricity generation capacity, and 100kW distribution capacity. Most grid-connected generation capacities are quite large as the Nigerian Bulk Electricity Trading PLC prefers to purchase generation capacities above 50MW due to transmission losses. It therefore implies that most grid-connected electricity is derived from large plants, from sources such as large and medium hydropower and large Gas-fired thermal plants currently. Thus, the REA can only support the grid connection at the distribution level, by providing transformers, distribution cables, concrete poles etc.

Figure 2.8 below shows the map of Nigeria showing existing national grid as at September 2012:

Figure 2.8: Map of Nigeria Showing Existing National Grid, 2012



Source: Transmission Company of Nigeria (TCN) 2013

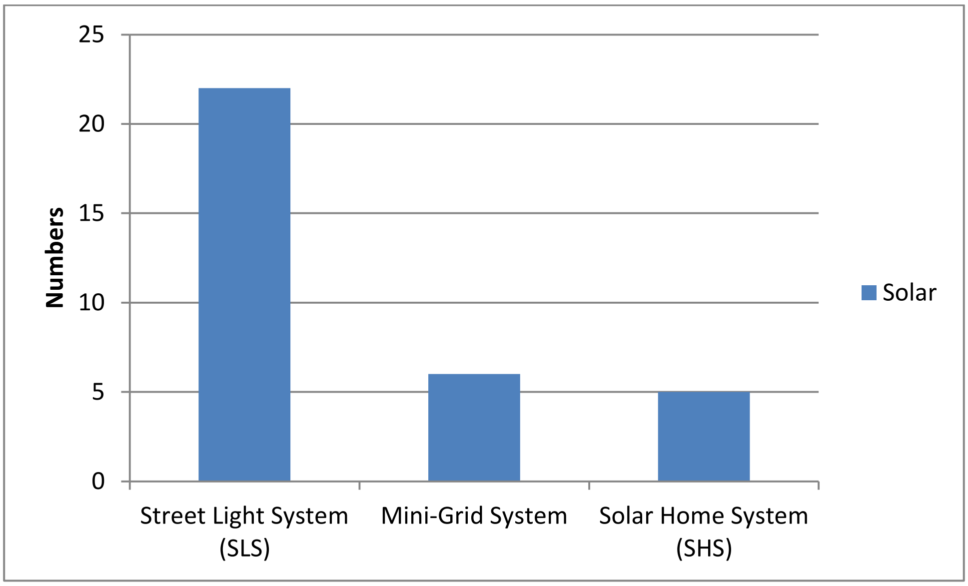
In order to improve the cost-effectiveness of grid extension for rural electrification, there is the need to strive to lower electricity costs associated with labour intensive work such as monthly meter reading or electricity billing in rural areas with low load density and sparse population; reduce non-technical losses mainly due to electricity such as theft, vandalism etc. Therefore, a community-participatory model that involves operation and maintenance cost for the project, including collection of electricity tariffs, should be encouraged by moving the project from the distribution companies to a local cooperative, local government or local NGO.

2.3.3.2 Off-grid and Mini-grid Electrification

For remote villages, it is often considered that off-grid and/or mini-grid solutions are more cost-effective. The mini-grid electrification is a system of providing electricity to each household by setting up a centralized system (mini-grid), which could be a central PV plant in a village that is converted to alternating current (AC) using an inverter, or other technologies that involve using a diesel plant, or a hybrid of two or more technologies.

The draft RESIP proposes the development of mini-grid systems in the right circumstances, towards achieving the rural electrification objectives of the FGN. The REA has adopted Solar Mini-grid Systems for clustered settlements, Hydro Systems: Mini-Hydro System (1-5MW), Micro-Hydro System (100KW-990KW) and Pico-Hydro System (100W-300W), Wind technology, Biomass and Hybrid Systems as technologies to be used for Mini-grid electrification in Nigeria.
The REA has also embarked on some mini-grid projects as shown in figure 2.9 below:

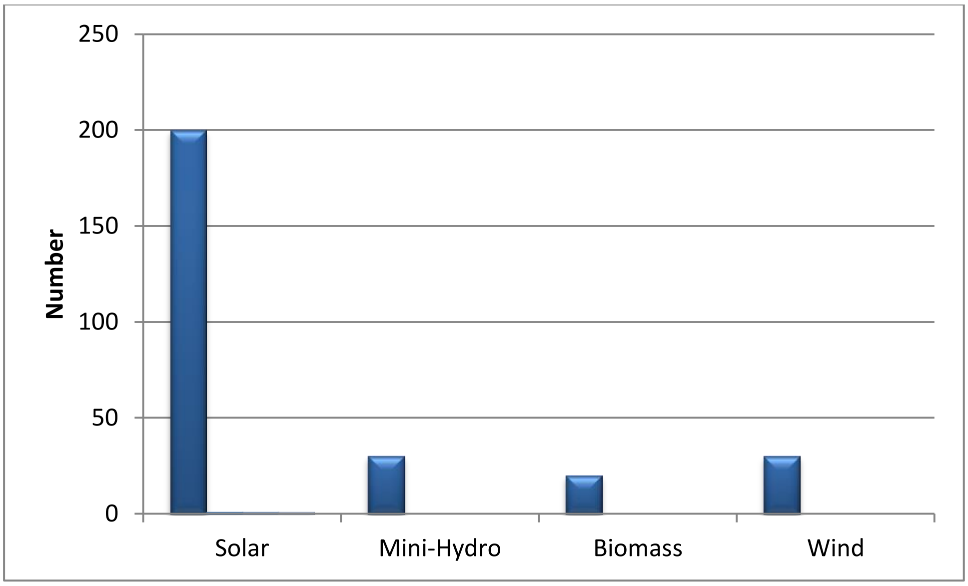
Figure 2.9: REA Off-Grid Projects Status 2006 - 2009



Source: Rural Electrification Agency (2012)

The REA also plans to carry out some off-grid projects as shown in figure 2.10 below:

Figure 2.10: REA planned Off-grid Projects 2013-2015



Source: Rural Electrification Agency (2012)

Many state governments and the capital city (Abuja) have used solar technology for street lighting, schools and motorized boreholes. The Energy Commission of Nigeria (ECN) has also initiated a couple of off-grid rural renewable energy projects in various parts of the country. According to

Sambo A.S. (2007), some of these projects include: the 5.5kWp solar PV plant at Laje in Ondo State, Solar Street lighting in Yenagoa, Bayelsa state, solar PV plant at Shanono LGA of Kano State, Solar PV at Ini LGA in Akwa Ibom State, 2.8kWp solar PV plant at Itu-Mbauzo in Abia State, 5kW aero generator in Sayya Gidan Gada, Sokoto State.

Iloeje, O.C. (2004) also listed some pilot projects carried out by ECN to include: Kwalkwalawa Village Electrification with Solar in Sokoto State (covers forty households, 8 shops and a school, installed in 1994), Solar PV plant at Iheakpu-Awka, Enugu State (covers 50 homes and village square, installed in 1998), and the Solar Water Pumping installed at the Federal Government College Kwali Abuja, by the Education Tax Fund in 2003. Others include the Rice Drying Solar-thermal project installed in 1991 at Adani, Uzo-Uwani LGA of Enugu state, Solar-thermal Chick brooding at Nsukka and Adani, Solar Cookers, Solar water heater, Biogas Generator in Mayflower School, Ogun State, and Improved cook-stoves.

The Solar PV technology has gained more acceptability in Nigeria compared to other off-grid technologies which are gradually being explored. Over 40 companies were engaged in Solar PV sales and installation activities according to Iloeje, O.C. (2004). A lot of state governments including the Capital City (Abuja) and Local governments have embarked on various off-grid projects over the years. The common ones are solar street lighting, solar traffic lights and solar motorised boreholes.

A bulk of the off-grid projects are being financed by government at various levels. Private investors and individuals are yet to fully tap into the market. However, most of the installed off-grid and mini-grid systems were not sustained for long due to lack of maintenance in most cases, lack of replacement/sustainability plan, vandalism and theft. Bhattacharyya (2011) opined that total commitment on the part of government, effective rural electrification agency, a clear road map and effective implementation plan are the necessary ingredients needed to stir up the renewable energy market for rural electrification.

2.3.3.2 Stand-alone Systems

As a solar home system (SHS) typifies a stand-alone system, it refers to a form of electrification through a form of dispersed power installed at the site of a consumer. The advantage of this system is in its sense of ownership derived by the consumer compared to mini-grid and grid electrification. It is also good for areas with low levels of demand where mini-grids would not be feasible. The REA proposes to use factors such as terrain, technology type, distance, economic profile and population density in determining the most cost-effective type of rural electrification project to develop in each site. The draft RESIP proposes the following policies:

- Ensuring minimum quality and safety standards should be established to manufacture and install equipment; other regulations should not be increased unless absolutely necessary;
- Reduction of import duties on equipment used for renewable energy use;
- Promoting the production of renewable energy equipment locally

As at 2009, over 60 million Nigerians were estimated to own independent stand-alone diesel or petrol electricity generating plants, and it costs them approximately $13.35 million to fuel and maintain these plants annually[30].

This shows that households are willing to pay for electricity if it is available, reliable and affordable. Nigeria's Rural Electrification Agency (REA) which initiated over 2000 rural electrification projects had its activities halted in 2009 due to corruption and contract scam allegations. However, the agency was restructured and reopened for business on January 16th, 2012. Thus, more rural energy projects have been commissioned since its reopening[31].

2.4 Overview of Nigeria's Rural Electrification Policy (REP) 2009

The FGN developed the draft REP in 2005, revised it in 2006 and the officially approved in 2009. However, the REP has not helped much due to

[30] See ECN website at http://www.energy.gov.ng/index.php?option=com_content&task=view&id=51&Itemid=58

[31] See http://www.punchng.com/business/business-economy/1994-rural-electrification-projects-uncompleted-rea/ (last visited on 5th of June, 2012)

the need to also develop a Rural Electrification Strategy and Implementation Plan (RESIP), Rural Electrification Master-plan (REM), as well as a Terms of Reference (TOR) of rural electrification survey, to go with the REP, which are currently in their draft stages as at April 2014. However, this lack of RESIP has slowed the progress of rural electrification in Nigeria, and also prevented the REA to effectively engage multilateral/bilateral donor agencies and other corporate bodies for funds, as they would not deal with the REA without a RESIP.

The REP (2009) lays the ideological foundation through which all rural electrification activities will be approached. Amongst some of these objectives are:

The objectives of the FGN's rural electrification programme as contained in the REP are to:

i. Promote agriculture, industrial, commercial, and other economic and social activities in rural areas;
ii. Raise the living standards of rural populations through improved water supply, lighting and security;
iii. Promote the use of domestic electrical appliances to reduce the drudgery of household tasks typically allocated to women;
iv. Promote cheaper, more convenient and more environmentally-friendly alternatives to the prevalent kerosene, candle, and vegetable oil lamps and fossil fuel-powered generating sets;
v. Assist in reducing migration from rural to urban areas;
vi. Protect the nation's health and environment by reducing indoor pollution and other energy-related environmental problems.

In order to achieve these objectives, the FGN intends to employ the following measures:

i. Improving service standards, including increased availability, reliability, and quality of power supply;

ii. Improving affordability of power through competition, subsidies on capital investments, and reduced barriers to entry, among others; and
iii. Improving financial sustainability of power supply, through appropriate tariff policies that reflect costs of operation & maintenance, system expansion and upgrade, and a reasonable return on investment.
iv. Promoting awareness of renewable energy resources

Furthermore, to promote rural electrification in Nigeria, several other policy instruments have been created such as the following:

1. Tariff Policy: In line with international best practices, and the EPSRA 2005, cost-reflective tariffs are to be adopted for rural electrification. REA will develop an appropriate formula for calculating the tariff for rural electrification in consultation with NERC and negotiations between suppliers and consumers. Such tariff is expected to cover suppliers' costs with some profit margin, as well as being affordable to consumers.
2. Regulatory Policy: The EPSRA 2005 empowers the REA to regulate residual areas that are exempted from NERC regulation. REA responsibilities in this regard includes: monitoring and enforcing safety and technical standards, tariffs and payments, quality of service, consumer protection, use of network equipment, and dispute resolution. The REP also provides for the scope of REA regulation to include any generation capacity less than 1MW, and distribution systems with less than 100Kw capacity, as well as off-grid and other capacity as NERC may determine from time to time.
3. Promotion of Low-Cost Technologies: For rural electrification, the FGN's policy is to promote the use of low-cost but high quality options, which includes renewable energy systems and grid extension here required.
4. Involvement of Non-Traditional Operators: The FGN's REP encourages the involvement of non-traditional operators such as NGOs, community-based organizations, private sector entities,

towards stimulating new entries to the market. The REA would create awareness among potential market participants about opportunities available in rural electrification business via the REF, as well as partnership opportunities.

5. Capital Subsidies: Subsidies and funds will be granted to eligible rural electrification projects based on the provisions of the EPSRA 2005. Selection of such projects shall be done transparently, efficiently and competitively.
6. Promoting Least-Cost Equipment and Capacity Building: it is the FGN's policy to vigorously pursue a policy of tax and duty reduction on renewable electricity generation equipment and low-cost supplies tries to of rural electrification materials, while preparing the grounds for Nigerian industries to manufacture these items of equipment locally.
7. Regional Equity: Given Nigeria's diverse nature, it is the FGN's policy to ensure equitable distribution of rural electrification projects to reflect the federal character of Nigeria. Therefore, each geopolitical zone in Nigeria will have equal access to the Rural Electrification Fund (REF).
8. Rural Development: The FGN intends to use rural electrification as a tool for rural development. Given the importance of electricity to rural areas, especially in reducing the time devoted to gathering wood-fuel for energy, and having more time for productive use, there is no doubt, that rural economies would improve and grow. It is the FGN's policy to promote rural electrification towards achieving a broader objective of rural development.

Furthermore, as part of implementation plans and strategies of the REF, the FGN proposes to do the following:

i. Adopt the Draft Rural Electrification Strategy and Implementation Plan (RESIP) by the Ministry of Power (MOP) and the Federal Executive Council (FEC);

ii. Constitution and appointment of a new Supervisory Board for REA (this was done in September 2013);

iii. Developing a comprehensive Rural Electrification Master-plan (REM) for Nigeria, in collaboration with the Japan International Cooperation Agency (JICA);

iv. Funding the REF;

v. Developing a Rural Electrification Database indicating present access and outstanding coverage (this is an area this research also covers);

vi. Completion of over 1900 on-going rural electrification projects commenced under the NREP of the FMPS; and

vii. Development of a Rural Electricity Users Cooperative Societies (REUCS) towards establishing Electricity Cooperatives to own and maintain Rural Electricity Networks.

viii. Collaborate with NGOs, donors, Bilateral and Multilateral institutions, Commercial banks, etc. in order to source funds for the REF;

ix. REA has completed the first phase of sites identification, studies and design of pilot off-grid renewable energy generation and supply projects and is ready to deploy this to the six geo-political zones in collaboration with Private Sector Participants;

x. As provided for in the EPSR Act (88a,b,d & f), REA is in discussions with NERC on the method of payments of levies and fees from power sector participants and consumers to be applied to the REF;

xi. The process of running the REF as provided for in the EPSRA Act, 2005; requires that all monies appropriated by the National Assembly for rural electrification capital projects including constituency projects should be paid entirely into the REF;

xii. Engage NERC in discussing regulatory guidelines for rural electrification schemes exempt from NERC regulation;

xiii. In collaboration with the Ministry of Power and NERC, establish the Power Consumer Assistance Fund (PCAF);

xiv. Promote REA activities and projects through sensitization campaigns and raising awareness starting May 2012;

xv. Effective collaboration with NGOs, private sector participants, Bilateral and Multinational organisations, such as JICA, EU/G12, the World Bank, VDI, UNIDO, WEMA bank, etc. for development of off-grid renewable energy systems in the rural areas.

In laying out the procedure for implementing rural electrification projects under different sources of funds, the FGN has adopted the following in its REP (2009):

A. FGN Funded Projects (Pre-Privatization and New Projects):
- Evaluate electrical load demand and carry-out commercial survey of proposed community;
- Develop Project Designs;
- Develop Bill of Engineering Measurement and Evaluation (BEM&E)
- Carry-out project bids and award contract based on Nigeria's 2007 Procurement Act;
- Monitor and supervise project to raise payment certificates
- Carry-out pre-commissioning test and inspect completed project; and
- Formally commission project for use by rural community.

For on-going FGN Funded Projects carried over from the NREP, the REA is expected to also:

- Monitor and supervise project to raise payment certificates
- Upon completion, do a pre-commissioning test and inspect project; and

- Formally commission project for use by rural community

More so, ownership for off-grid renewable energy projects will reside with the community according to the draft RESIP. This will be done through the Rural Electricity Users Corporative Societies (REUCS) or representatives of the community, who are also expected to conduct Operation and Maintenance (O & M) of systems, in the course of project execution.

A. Specific Donor Funded Projects: The REA would carry out site identification and selection in this case or jointly with donor agencies, where necessary. Project design could also be carried out jointly with donor agencies and REA or exclusively by donor agency where they have the technical know-how. In a situation where the donor agency wishes to sustain ownership and management after project completion, REA can work with them to develop a sustainable business model.
B. Post-Privatization:
    - REF would be the basis for project implementation, and all eligibility and selection criteria for the disbursement of the Fund will apply;
    - The privatized distribution companies would be the owners of any grid extension projects funded by the FGN; and
    - The REUCS would be owners of off-grid renewable projects, whether funded by FGN or donor agencies.

From the foregoing, it can be observed that while all the plans for rural electrification in Nigeria seem watertight, it is all still majorly a draft, especially the Rural Electrification Master-plan (REM) and (Rural Electrification Strategy and Implementation Plan (RESIP). As at April 2014, the REA only relies on the EPSRA 2005 and a limited REP to carry out its function, which does not provide a clear-cut direction on how to proceed, but only establishes the REA, REF, PCAF and NERC, and stated what should be their roles in the industry under the new reforms.

Therefore, not much has been achieved in terms of the rural electrification policies and objectives in Nigeria. Most bilateral and multilateral agencies that would have supported the REA cannot at the moment, as the REA has no official REM and RESIP. It is hoped that these documents are made official soon, so that the REA can completely take-off and commence implementation of Nigeria's rural electrification objectives.

As at April 2014, the RESIP was still being reviewed after the initial draft was sent back to the Minister of power by the president of Nigeria with his feedback. The minister then constituted a committee to review the draft to accommodate the president's input. The researcher was privileged to be part of the committee currently working on the draft alongside other stakeholders from the industry. It is hoped that the document would be published and adopted before the end of the third quarter of 2014.

2.5 Organisational arrangements for regulation of rural electrification in Nigeria

According to the National Energy Policy NEP (2003), Nigeria's energy planning and policy implementation is centralized and carried out at four distinct levels. These levels are: National level, Sectoral level, Sub-sectoral level and Operational level.

At the national level, the National planning commission in collaboration with various stakeholders in all sectors, designs the overall developmental objectives, policies and plans for the country.

The sectoral level involves overall sectoral planning, monitoring, management and implementation of Nigeria's energy sector policy. At this level, there is harmonization of sub-sectoral energy plans and policies with the general national energy policies and objectives.

The Sub-sectoral level, a host of ministries manned by various ministers, are in charge of ensuring that more precise sub-sectoral plans and policies are implemented toward exploiting a particular energy resource such as electricity, oil and gas, and solid minerals. The Ministries of Energy, Petroleum Resources, Mines and Steel, Water Resources, and Science and Technology all have stakes in the development of rural electrification in

Nigeria. However, the Ministry of Power is directly in charge and reports directly to the president of the Federal Republic of Nigeria. This leads to lack of harmonization of policy thrusts, which affects rural electrification in Nigeria.

At the operational Level, actions involving implementation of plans and objectives developed at the Ministerial level are carried out by a multitude of agencies and parastatals such as the Energy Commission of Nigeria (ECN), Nigerian Electricity Regulatory Commission (NERC), Nigerian Bulk Electricity Trading (NBET), Rural Electrification Agency (REA), Nigerian Electricity Liability Management Company (NELMCO), National Power Training Institute of Nigeria (NAPTIN), Nigerian National Petroleum Corporation (NNPC), Successor companies of the now defunct Power Holding Company of Nigeria, (PHCN)-Transmission Company of Nigeria (TCN), and Distribution Companies (DisCos), Generating Companies (GenCos)[32]. Other agencies of government that are not directly involved with electricity supply, but have a role to play via cross-sectoral interfacing, includes: the Central Bank of Nigeria (CBN), Nigerian Customs Service (NCS) and Nigerian Ports Authority (NPA)[33]. Most of these agencies are currently members of the committee reviewing the draft RESIP in Nigeria as at April 2014.

As part of moves to decentralize the energy sector, the Federal government of Nigeria in Mach 2012, through the NERC devolved some powers to state governments, private individuals and communities, and granted them permits to embark on generating their own electricity. These permits came under two regulations issued by NERC on the 7th of March 2012, named: *NERC Regulation on Embedded Generation 2012*, which permits all tiers of government, communities and investors to generate and distribute electricity for their special consumption needs, using existing grid facilities, while the *NERC Regulation for Independent Electricity Distribution*, permits

[32] *Ibid* note 7
[33] *Ibid* note 11

them to invest in electricity distribution networks in areas that lack access to national grid[34].

For rural electrification, the EPSRA 2005 mandates the REA to regulate all rural electrification programmes that are exempt from NERC regulation. While rural electrification schemes will be mainly self-regulating and guided by contracts/agreements, the REA is mandated to monitor and enforce such contracts between consumers and suppliers, towards protecting both. Therefore, REA's regulation mandate would be centred on the following components:

i. Decreasing barriers to market entry
ii. Reducing the regulatory compliance and burdens associated with burden
iii. Applying more relaxed oversight of tariffs; and
iv. Scaling back quality of service standards while making sure that basic health and safety issues are covered.

Principal areas also required to make sure that basic requirements are met include:

i. Implementation of license conditions
ii. Execution of a Consumer Protection Code
iii. Quality of service;
iv. Dispute resolution and contract enforcement;
v. Payment of agreed tariffs and conformity with tariff terms and conditions;
vi. Safety and technical standards; and
vii. Protection and proper use of network equipment.

The EPSRA 2005, therefore devolves some regulatory and oversight powers from NERC to REA, towards ensuring decentralization and effectiveness on the part of REA. However, these powers of regulation for REA are only for

[34] see http://www.bellanaija.com/2012/03/19/new-electricity-regulation-in-nigeria-seriously-better-power-supply-or-what/ (last visited on 8th of June, 2012)

rural electrification generation projects of less than 1MW capacity, and 100kW aggregate distribution capacity.

Lessons from the Chinese rural electrification experience show that, although decentralization of the energy sector will allow for a faster pace of rural electrification development, care has to be taken to avoid unnecessary bureaucratic bottlenecks, power tussle and duplicity of functions amongst the various agencies[35].

2.6 Financing rural electrification in Nigeria

The financing of rural electrification projects in Nigeria can be classified into two phases: Financing under the Pre-reform Era (1914 to 2005) and financing under the Reform/Current Era (2005 till date).

2.6.1 Financing rural electrification in the Pre-reform era

During this era, financing of rural electrification projects was carried out solely by the Federal Government of Nigeria (FGN) through its Ministries and agencies responsible for the energy sector. The now defunct Nigeria Electric Power Authority (NEPA) was the government's owned integrated monopoly in the electricity sector that was in charge of generation, transmission, distribution, rural electrification and sale of electricity to consumers[36].

The Federal government through NEPA decides what energy resources and technology to use, where to site the project, and who to award the contract to. This process was usually done in secrecy, devoid of transparency and open bidding, it was also supply focused and politically motivated, rather than done for social or economic concerns (ESMAP, 2005). Thus, it was bedevilled with corruption and favouritism, contract sum inflation, inefficiencies and mismanagement.

The government was not able to generate enough electricity to meet the demand during this era due to the huge costs involved in building power

[35] Bhattacharyya, S.C., and Ohiare, S.M., (2012), the Chinese Electricity Access Model for Rural Electrification: Approach, Experience and Lessons for Others. Energy Policy, 49; 676-687
[36] *Ibid note 4*

plants and the fact that NEPA (who had a weak financial base) was a monopoly that did not allow for competition and market forces to operate. The government also had other competing needs from various sectors, coupled with large scale corruption and embezzlement of government funds prevalent at that time.

Emphasis was also not given to rural electrification until around 1981, when government via NEPA embarked on a national rural electrification project to connect all Local Government headquarters to the national grid (Bhattacharyya, S.C., 2011). Although, about 600 out of the 774 Local Government Headquarters were successfully connected to the grid, distribution network to various rural communities remained slow in some areas and non-existent till date in others, due to lack of funding from government (ESMAP, 2005).

2.6.2 Financing rural electrification in the reform/ current era

When it became obvious that the FGN alone could not bear the burden of funding electricity supply projects to meet the ever growing demand within a realistic timeframe, there was the clamour for urgent reforms and restructuring of the Electricity Sector to meet up with the challenges and realities of the 21st century.

The EPSR Act 2005 provides for a strong and independent electricity sector regulator called the NERC, which has since been established and follows a Multi-Year-Tariff-Order (MYTO) that would gradually remove government control of electricity prices, and bring about a cost reflective tariff. The latest increase in prices took effect from June 1st 2012. This is to build investors' confidence and attract them into investing in the sector.

The reforms also involve the privatisation and commercialization of Nigeria's electricity sector, away from the past practice where NEPA monopolised all activities in the sector. Thus, financing under this era entails a mix of models, such that the Federal Government, State Governments, Local Government, Communities, Private investors, Bilateral and Multilateral institutions would all contribute towards funding electricity projects, while the NERC and REA regulates their activities. Details of how rural electrification will be financed during this era are provided in Chapter 5.

2.7 Constraints to expanding rural access to electricity in Nigeria

Some of the constraints and barriers hindering electricity access in rural areas of Nigeria have been highlighted in subsection *1.1.1* as provided by ESMAP 2005. In addition to these, the draft Rural Electrification Strategy and Implementation Plan (RESIP) 2012 also suggests Technical Capacity, Financing, Economics, Demand, Supply, and Planning as some of the barriers to rural electrification in Nigeria.

However, as part of its proposed strategy and implementation plan, the REA intends to promote developing renewable energy curriculum in tertiary institutions of Nigeria and extending technical assistance to such institutions where required. The aim is to increase the level of technical capacity required for rural electrification as quickly as possible.

To this end, FGN pledged to provide subsidies towards capital costs, and lowering electricity tariff for rural consumers. The REA also intends to include plans for operation and maintenance, as well as cost effectiveness of off-grid and grid systems of any rural electrification programme under consideration for REF grant, towards improving the perception of the fundamental economics of the rural electrification arrangement.

In terms of planning and coordination of rural electrification programmes across the nation, the REA through its draft RESIP proposes to establish projects based on demand as opposed to top-down government planning. While projects would be carried out at Federal, State and Local levels, overall coordination should be done by the REA to allow for efficiency and prevent avoidable gaps and overlaps. In this vein, responsibilities of the Corporate Headquarters and Zonal offices of the REA are clearly defined in the REP.

The draft RESIP also reported the issue of demand and supply as barriers to rural electrification in Nigeria. While rural dwellers eagerly want and need electricity, they cannot back it up with the ability to pay, which causes a demand problem. Under the new reforms, the strategy is for rural dwellers to pay for electricity, even though the FGN would make available subsidies and other cushioning measures. It is the responsibility of the REA to create the awareness to rural communities about the government's new stand on this.

However, on the supply side, there is a general lack of interest from the private developers to invest in rural electrification. Under the draft RESIP, the REA recognises this barrier and proposes to lure project developers through effective outreach approaches of opportunities available through the REF and proper incentives.

2.8 Gas to Power Status in Nigeria

Given the increasing interests and investments in gas-fired electricity generating plants in the power industry of Nigeria by private investors (see tables 2.3 and 2.4 above), the role of gas in the generation of electricity in Nigeria is crucial. This is because gas is not only environmentally friendly and a clean source of energy, it is also found in abundance in Nigeria, and relatively cheap. However, the low gas price has limited investments in gas production and supply, which poses a challenge for gas-to-power initiatives in Nigeria.

Nigeria has proven natural gas reserves of approximately 182 TCF (trillion cubic feet), which makes the country's gas reserves the 7th largest in the World (Odumugo, 2010). Nigeria's gas quality is high, with little or no sulphur, low CO_2 and rich in liquids (condensate) content. However, according to (Akachidike, 2008), the country's gas flaring activities is among the top in the world, accounting for 16% of global gas flare. This is generally attributable to the unattractive gas price currently obtainable in the domestic market of Nigeria, which acts as disincentives for investments by gas producers in the country, as it is cheaper for them to flare the gas and drill oil for a good price, than to invest in gas production without adequate returns.

Thus, exporting gas to the international market in the form of Liquefied Natural Gas (LNG) is more profitable than utilizing gas for power generation or domestic consumption in the country. All gas-fired IPPs that approach the Nigerian Bulk Electricity Trading PLC (NBET) for a Power Purchase Agreement (PPA) in an unsolicited bid for power generation category, is given a due diligence check list. Amongst this due diligence is the provision for gas supply to the plant, which must involve a Gas Supply Agreement (GSA) between a private gas supplier or the Nigerian Gas Company (NGC), and the IPP[37].

According to the Multi-Year Tariff Order (MYTO) of the Nigerian Electricity Regulatory Commission (NERC), gas price for new entrant Combined and Open Cycle Gas Turbines from 2012 is put at $1.8/MMBTU[38], and this price is only available if the gas supplier is the Nigerian Gas Company (NGC) (a government owned company). However, other private gas suppliers sell at much higher prices, thus, an IPP has to negotiate a good deal for gas supply to the plant, which is usually above the NGC price but reasonable enough to keep the tariff stable, as such gas prices are subject to the approval of NERC. The NERC is concerned about gas prices for power projects because it is a 'pass through' cost to the electricity consumers, charged to the retail tariff. Therefore, NERC tries to protect the consumers by negotiating a fair gas price for consumers, while also allowing for reasonable returns for the gas supplier.

As part of efforts to drive investments in the gas sector and facilitate gas to power, the Federal Government of Nigeria (FGN) embarked on major gas reforms in 2008 by passing the Nigerian Domestic Supply and Pricing Regulations 2008 into law as well as developing the Nigerian Gas Master Plan (NGMP) 2008. However, the Petroleum Industry Bill (2012 draft) which

[37] Source: based on researcher's internship experience at NBET.
[38] See MYTO for Generation at http://www.nercng.org/index.php/document-library/func-startdown/67/ (Last visited 30th of June 2014)

is expected to provide new regulations and guidelines for gas related issues, is yet to be passed into law by the National Assembly, and this has stalled investments into the gas sector due to uncertainties and investor speculations. Amongst some of the challenges of domestic gas market are:

- Demand: there is an unprecedented increase in the demand for gas at domestic, regional and international export levels.
- Infrastructure: There is an inadequate gas transportation and processing facilities in Nigeria;
- Price: The increase in gas prices globally compared to the capacity of domestic gas buyers to pay in Nigeria; and
- Commerciality of Supply: The gas sector in Nigeria has a history of poor performance in terms of commercial performance, such as non-payment of bills, low prices, weak and unenforceable GSA.

The FGN also established a 'gas aggregator' called the Gas Aggregator Company of Nigeria (GACN), which was incorporated in 2010. The GACN was created to act as the first point of contact for gas buyers for domestic use, and manage all domestic gas supply obligations volumes. The GACN's role is majorly to engage in demand management until the end of Government's intervention in the gas sector through the Domestic Supply Obligation (DSO). They also engage in network and system administration, provide Aggregate Price, securitization and escrow management services until the end of the first set of GSA. The DSO was introduced by the FGN to ensure availability of gas for domestic gas utilisation projects. This mandates all oil and gas operators to set aside a pre-determined amount of gas reserves and production for the domestic market.

In the light of the foregoing, it is evident that the FGN is currently transforming the gas sector to become more structured and commercialized, this needs to be vigorously pursued and implemented. However, going forward, there is the need for the National Assembly to pass the PIB as soon as possible to bring about the proposed new regulations and guidelines for the sector into fruition, which will allow private investors to make informed investment decisions in the sector based on the new laws and regulations. There is also the need to review the current domestic gas and electricity prices as well as get the gas monetisation economics right to attract more investments in the sector.

In conclusion, given the abundance of gas in the Niger Delta region of Nigeria, rural electrification in such areas can take comparative advantage of its gas resources and embark on using gas related technologies such as gas generators for rural electrification. The REA also needs to encourage and promote such technologies going forward. There is also a critical need to implement the existing commitment to end gas flare by oil companies.

2.9 The West African Power Pool (WAPP)

The West African Power Pool (WAPP) was launched on the Authority of ECOWAS Heads of State and Government via Decision A/DEC.5/12/99, during their 22nd Summit, with the objective of stimulating power supply in the West African sub-region. The WAPP vision is to: "Integrate the operations of national power systems into a unified regional electricity market, which will, over the medium to long term, assure the citizens of ECOWAS Member States a stable and reliable electricity supply at competitive cost"[39] .

The WAPP covers 14 of the 15 West African countries, i.e. Benin, Côte d'Ivoire, Burkina Faso, Ghana, Gambia, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo. The headquarters of WAPP is in Cotonou, Benin Republic. The WAPP roadmap adopts a two-track approach of dividing the West African countries into zone A and B, towards prioritizing the development of the power system in the region. Zone A consists of Benin, Burkina Faso, Côte d'Ivoire, Ghana, Niger, Nigeria and Togo; while zone B consists of The Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Senegal and Sierra Leone. The WAPP is regulated by the ECOWAS Regional Electricity Regulatory Authority (ERERA) established in 2008.

[39] See WAPP website at http://www.ecowapp.org/?page_id=6 (last visited on the 2nd of July, 2014)

The intentions of WAPP according to their Business Plan are to establish a robust interconnection link between the national power systems of WAPP zone 'A' countries; interconnect national power systems of WAPP zone 'B' and secure low cost access to hydroelectricity sources; to establish an Inter-Zonal transmission hub from sources of low cost energy such as large hydro and gas-fired plants to other areas within the zone that rely on diesel-based sources; and to upgrade existing capacity to transfer low cost energy supply produced from hydro sources in Nigeria and transmitted to Niger, Benin, Burkina Faso and Mali.

The arguments in favour of having a large or regional power pool according to Sebitosi and Okou (2010) are: reduction in capital and operating costs through improved coordination among utilities; improved power system reliability, enhanced security of supply, optimization of generation resources with large units; improved investment climate through risks pooling; increase in inter-country electricity exchanges; coordination of generation and transmission expansion; and development of a regional market for electricity. However, they also posited that the expectations from such large electric power infrastructure had been over-stated, as current researches seem to focus on distributed power generation rather than trans-continental power grids, as this enhances increased consumer participation and reduced transmission losses. They believe that centrally managed large power grids as proposed and propagated by Nicola Tesla in 1883 are now obsolete, having served the power industry for over a century.

The FGN has been in the forefront of promoting the WAPP, and it is central to the reforms of the power sector. As part of the WAPP initiatives, Nigeria currently supplies approximately 200MW of power to Benin and Togo through a contract with Benin's power grid company - Communauté Electrique du Bénin (CEB)[40]. Further, Nigeria also supplies approximately 100MW of electricity to Niger Republic via contractual arrangements with

[40] See http://www.afdb.org/en/news-and-events/article/benin-nigeria-power-interconnection-project-sharing-energy-in-west-africa-11791/ (last visited on the 2nd of July, 2014).

Société Nigerienne d'Electricité (NIGELEC)[41]. However, critics of this policy have condemned these arrangements based on the fact that Nigeria currently lacks enough generation capacity to take care of its domestic market demand; thus, it makes no sense to export electricity to neighbouring countries.

Therefore, while the WAPP initiative is a good one with numerous advantages for member states, it is imperative for Nigeria to first embark on developing her electricity sector (generation, transmission and distribution) to meet domestic demand, before exporting excess generation to neighbouring countries.

2.10 Summary

This chapter looked at rural electrification status in Nigeria. Issues of Financing, technology choices, governance and challenges were highlighted. Findings from the chapter shows that despite being endowed with abundant energy resources (fossil fuel and renewable), and 9 years after enacting the EPSR Act towards restructuring the electricity sector in Nigeria, coupled with sinking billions of dollars into the sector, Nigeria has failed to solve its electrification challenge in general and rural electrification in particular.

The chapter shows that Nigeria's case is that of lack of political will and genuine commitment on the part of government[42]. Although the government has gradually started implementing the EPSRA and developed a roadmap for its actualization in August 2010, the government has clearly missed some of its major timelines in this regard, which makes the roadmap unrealistic and impractical. The government is also slow in making relevant documents official, such as the Rural Electrification Master-Plan (REM), and Rural Electrification Strategy and Implementation Plan (RESIP). All these documents are still at draft stages 9 years after the current electricity reforms started.

[41] See http://www.mbendi.com/indy/powr/af/ni/p0005.htm (last visited on the 2nd of July, 2014).

[42] Bhattacharyya S.C., Off-grid Electrification Outside South Asia-Status and best practices, at http://www.oasyssouthasia.info/docs/oasyssouthasia-wp2-sept2011.pdf (last visited on 21st of June, 2012)

It is therefore imperative for the FGN to as a matter of priority to provide the enabling environment to allow more players (state governments, private sector, micro-finance organisations and foreign investors) come into the electricity sector of Nigeria at a decentralized level. Emphasis should be given to all energy resources with comparative advantage available to different parts of the country, and new sources of funding employed in order to achieve the required electricity supply for the people of Nigeria.

Most importantly, there is the need for various tiers of government in Nigeria to devise novel means of linking rural energy projects to rural entrepreneurship and economic development. This will solve the twin problem of lack of energy access and unemployment. Obstacles to investments must be eradicated, business enterprise encouraged, as well as cross-learning of experiences from countries of best practices such as China, Brazil, South Africa and others highlighted in chapter three of this thesis.

CHAPTER THREE
LITERATURE REVIEW

3.1 Introduction

Barnes (1988) defines rural electrification as: *"the accessibility of electricity for use by rural communities notwithstanding the sources, technologies and form of generation".*

Well-articulated literature abounds on financing rural energy especially in meeting the services of modern energy (electricity) demand in those areas where access has been characteristically low and challenging. Due to the huge size of population without access to energy in the world, which is estimated to be over 1.3 billion in 2009 as reported by IEA (2011), there is the need to constantly explore means and ways to tackle this energy access challenge especially in the most vulnerable rural areas of Sub-Saharan Africa and South-Asia.

However, not much has been done in the area of financing rural energy projects especially in Nigeria. Studies such as IEA (2011), concentrated on a macro level analysis of estimating financing requirements and flow for different regions and technologies, while Bazilian et al. (2011) was more focused on the flow of finance from international sources.

Glemarec (2012) identified ways of using public resources to attract the private funds. However, studies such as Monroy and Hernandez (2008) and (2005) did a more micro analysis to determine stakeholder perspectives via a survey. Mainali and Silveira (2011) while using Nepal as a case study, found that there is still a huge financial gap between the cost of electrification and affordability, despite the increase made in renewable energy technologies' use and awareness and willingness to pay by the people.

A study on Sri-Lanka was carried out by Hope (2006), while Liming (2008) did a comparison between China and India, and UNDP (2008) looked at various country experiences in financing options. An overview of the financing portfolio of the World Bank and Asian Development Bank were presented by Martinot (2001) and Delina (2011) respectively.

In the Sub-Saharan region, studies such as UNEP (2012) which looked at drivers and barriers for private finance in the region was only limited to renewable energy. Gujba, Thorne, Mulugetta, Rai and Sokona (2012) explored financial options available for Africa in moving towards a low carbon modern energy opportunities as well as markets, opportunities and risks associated with low carbon investment in Africa. Ohiare and Soile (2012) presented some lessons for Nigeria to learn from China's financing of rural electrification and ASER (2007) also reviewed the case of Senegal.

Most other studies on the region have focused on either the technological, institutional, policy, cost-benefit or renewable energies aspect of rural electrification. Some of these studies include: Ajao et al. (2011) who used the HOMER energy optimisation model to analyse the cost-benefit of a hybrid solar power in Nigeria, and Oseni (2012), who looked at the households' access to modern energy (electricity) services and pattern of energy consumption in Nigeria.

Further, Banks et al (2000) used a GIS based model to facilitate electrification planning, while Parshall et al. (2009) estimated investment requirements for rural electrification in Kenya using the spatial electricity planning and costs model. Others include Camblong et al (2009), Lemaire (2011) on off-grid solar systems use in South Africa, Haanyika (2006) on policy and institutional linkages, and Kemausor et al. (2012) on GIS based support for implementing policies and plans to increase access to energy services in Ghana, where the network planner model was developed. Results from these studies show bias towards grid connection in the long run, however, off-grid solutions were recommended for difficult areas where grid is currently unviable.

This thesis seeks to enrich electricity access and financing literature especially in Nigeria, as well as find suitable options and solutions for eradicating energy poverty in developing countries at an accelerated rate than what is currently obtainable. Thus, this chapter presents a review of literature on financing rural energy, with bias to rural electrification (renewable, conventional, off-grid, hybrid technologies etc.).

The main objective of this chapter is to review the different ways rural energy supply is being financed in the world, and identify emerging financing mechanisms that could contribute in significantly reducing the number of people without access to modern energy services, as well as identify best practices in this regard for developing countries to learn from.

Literature covering financing of rural energy projects, financing sources and mechanisms, integrating rural energy, private investments and rural development, and methodologies for analysing rural electricity supply, are reviewed in this chapter.

3.2 Review of UNDP Report on; 'Financing Options for Renewable Energy: Country Experiences' (2008)

This UNDP report (2008) looks at various country experiences in which RETs availability and energy services derived via RE has resulted in a rise in income, education, literacy, knowledge and awareness, improved health and a host of others. However, the report posited that it was difficult to show a clear picture of the causal relationship between the expanded use and availability of RE and the improvement in the living conditions of the rural dwellers.

The study looks at how the private sector can invest and finance rural energy technologies in order to meet the needs of the poor. Structured into two tracks, the study looks at; a) the place of RE in improving modern energy security and access to the poor, and b) the role and progress of RETs towards meeting the MDGs targets. Global and regional trends in RE investments were picked out, investments in RE of various programmes, initiatives and policies in the region were also examined to assess their effectiveness (case study of six (6) countries).

Findings from this research show that while reasonable investments were channelled into both RE projects and RE equipment's production, it is rampant in the rich countries of the North and a few developing/large countries such as India and China, as other Asian and Pacific countries have not made significant impact in this regard and poverty still remains high. Investments here are largely inspired by energy security concerns, increasing oil price, climate change issues and is majorly limited to grid-based RE and bio-fuels.

The study also found that through PPP, pockets of improvements have been gained in a few off-grid RETs in low income countries especially in the use of solar home systems (SHSs) and biogas units in households.

The approach and methodology adopted for the UNDP study included:

First, in order to determine how far access to RETs have gone in the rural areas, the study employed a list of indicators used to assess the suitability and sustainability of private investments in RETs towards poverty alleviation in the rural areas according to this study are;

a) Social Sustainability; where issues of (i) Access (ii) Affordability and (iii) Equity, were examined
b) Economic sustainability, and
c) Institutional stability.

Secondly, the study examines the impact RE has had on poverty alleviation using the Millennium Development Goal (MDG) goals and targets as a benchmark to estimate rates of successes and failures. This was done through case studies of six countries on the impact RE has made towards actualising the MDG goals, and supported with available literature reviews on the subject-matter.

A global assessment was carried out to see the achievements made so far towards private investments in RETs across the globe. Here issues bordering on bilateral/multilateral as well as international renewable energy programmes especially in developing countries were analysed.

Regional assessments covering North-East Asia, South Asia, South-East Asia, and the Pacific island regions, as well as national assessments covering Cambodia, Nepal, Bangladesh, Indonesia, Philippines and Solomon Islands were also carried out, all with the view of assessing how effective RE policies and projects have fared, challenges/obstacles and prospects of RE in meeting the needs of the poor, and consultation with major stakeholders in the industry to understand their various views for the future. In depth project specific case studies involving private sector investment and financing were also conducted.

The study faced a couple of challenges especially as regards accessing literature, project resources, data in developing countries and the fact that most RET projects are technology-oriented, which makes its findings and applicability to rural areas of developing countries unrealistic to a large extent. The fact that most of the resources discussed in this study that was channelled to RE did not get to those that need it the most especially those in rural areas of poor countries, buttresses the preceding point.

The study also focuses on RE without much emphasis on least-cost and practical technological options that can be deployed to providing access to electricity for rural areas of developing countries, also misses the point. This is because, cost-effectiveness of a project on the part of a project developer and affordability on the part of consumers are critical to developing a sustainable rural electrification project in countries that are worst affected.
Undoubtedly, the UNDP report (2008) has provided a lot of information for developing RE and ways of financing it, while some of its findings may be applied to Nigeria with some modifications others may not be practicable in rural areas of developing countries such as Nigeria. This is because of its focus on renewable energy only, which may not be the only option and cheaper option available for rural electrification in Nigeria. Thus, the need to

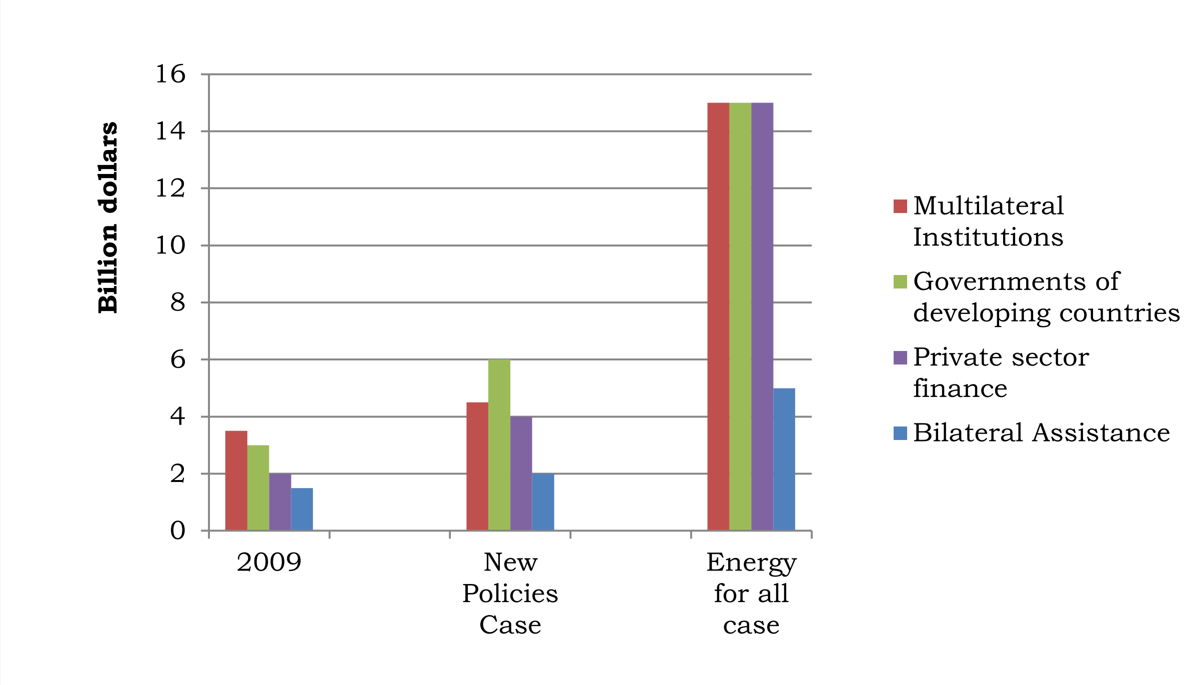
fill this gap by embarking on a more country-specific analysis, and providing innovative solutions and options based on their peculiarities.

3.3 Financing Rural Energy Access

According to Organisation for Economic Cooperation and Development/International Energy Agency – World Energy Outlook OECD/IEA WEO (2011), a huge size of increased investment is required to finance different energy technologies that will provide access to energy for all in 2030. While focusing on how these investments could be financed to achieve this feat, there is the need to note that a solid government and regulatory framework is also required to usher in these finances.
There is also need for Multilateral and bilateral organisations and NGOs to play the critical role of providing technical assistance, even though it is arduous to quantify the cost of these services. More so, these investments and finance sources would also depend partly on the best technology model (hybrid, grid, off-grid, stand-alone, mini-grid) suitable and required, as well as the financing instruments and sources appropriate for such investments.

An annual average investment requirement of $18 billion from 2010 to 2030 is estimated to be invested by international donor agencies and development banks in order to achieve energy for all globally within that period, while governments of developing countries are expected to invest an annual average of $15billion, as well as the private sector, which is estimated to inject around $15 billion investment annually too (IEA, 2011). Figure 3.1 below depicts this;

Figure 3.1: Annual Average Investment in Modern Energy Access by Source of Financing



Data Source: IEA 2011

A significant amount of the projected investments required to be provided by governments of developing countries will go into mini-grid projects and the diffusion of LPG for cooking especially to lower income households. The private sector on the other hand is projected to spend more on on-grid expansions projects and household biogas cooking systems especially for the higher income households since they will have the ability to pay for energy services[43]. An innovation is required as well, to develop a model for providing energy services that would be attractive to private investors and commercially viable. This will increase the share of private sector investments in the overall investments needed to achieve energy for all, especially if the structural bottle-necks are removed.

The IEA (2011) drew a contrast between lower household expenditure and higher ones, in appraising financing access to electricity and household cooking infrastructures. As regards electricity, they based such

[43]OECD/IEA, World Energy Outlook 2011, available at http://www.iea.org/Papers/2011/weo2011_energy_for_all.pdf (last visited on the 8th of February, 2012).

classification on the energy access business models report of the International Finance Corporation (IFC, 2012). The report estimates that around 50% of the 270 million households that currently don't have access to electricity, expend about $5.50 monthly on traditional energy for lighting purposes: they refer to this group as those belonging to the lower energy consuming households, while those above this group are higher energy consuming households. For cooking facilities financing, those below international poverty line that receive $1.25 or less income daily are the lower income group and those above are the higher income group.

Other estimates for guaranteeing universal energy access available in literature are: Bazilian et al. (2010), who estimates the annual costs under low, middle and high penetration scenarios to be $12billion, $60billion and $134billion respectively; The Advisory Group on Energy and Climate Change (AGECC) of the UN who also estimates between $35-$40billion annual investments for universal energy access. The African Development Bank - AfDB (2008) projected that between 2008 and 2030 there would be a requirement of $547billion to invest in 265GW towards achieving 90% electrification in rural Sub-Saharan Africa and 100% of the urban areas. Although, some of the assumptions employed to arrive at these estimates are debatable, the fact remains that the scale of investment required for realising universal energy in the world is enormous, and for this to be achieved, innovative ways of funding these investments from all sources are imperative.

This study provides some alternative funding options based on the aforementioned suggestions for Nigeria's case in chapter five, however, it is still unclear if the government of Nigeria will be committed enough to drive the process that can lead to the necessary changes required for these suggestions to work.

3.4.1 Financing Rural Electrification (on-grid)

The IEA World Energy Outlook for 2011 projects an additional yearly investment of $11billion on on-grid in the 'energy for all' scenario. They estimated that sixty per cent of this required amount will go into higher energy consumption households, where private investors will either go into Public-Private Partnership (PPP) arrangements to broaden the grid system or competitively bid for contracts and concessions to build generation plants together with transmission and distribution in a particular area. The attractiveness of the projects however, and reasonable tariffs to cover fair returns are crucial determinants of such private sector investments in this regard. Loans could be sourced by private investors from international banks and local banks, supported by guarantees from multilateral development banks, based on how attractive such projects are.

While some government-owned utility with the responsibility of ensuring energy for all may be able to get private loans from banks to augment internal finances, others may not be creditworthy enough to do so, and will require guarantees and support. If the right policies (tariff, bulk trader, strong regulations) and risks are properly allocated to parties best able to manage them, then the investment opportunities for on-grid financing, can be fully unlocked. Nigeria is an example of a developing country currently attracting a lot of investments in its electricity system, especially in generation of grid-connected power based on its current reforms. However, the same cannot be said for rural electrification due to the limited efforts in this area thus far.

Table 3.1 below shows a comparison of financing electricity access under the two scenarios considered in the IEA-WEO 2011 study. This thesis also carried out a scenario analysis in chapter five to see whether the current funding arrangements in Nigeria can sustain its rural electrification targets or not. Alternative funding scenarios based on the analysis done in chapter four were also suggested.

The IEA WEO (2011) also projected investment requirements for energy access under two scenarios: the 'access for all' scenario, and the new policies scenario. The 'energy for all scenario' examines what level of modern energy access might be achieved by 2030, while the 'new policies scenario' entails both existing and declared policy intentions of various governments in terms of energy access funding.

Table 3.1: Comparison of electricity access financing under the 'Energy Access for all scenario' and the 'new policies Scenario'

	Annual Investment ($billion)	People Gaining access annually (million)	Level of Household Energy expenditure	Main Source of Financing	Other sources of Financing
On-grid	11.0	20	Higher	Private sector	Developing country utility
			Lower	Gov't budget	Developing country utility
Mini-Grid	12.2	19	Higher	Gov't budget, Private sector	Multilateral and bilateral guarantees
			Lower	Gov't budget	Multilateral and bilateral concessional loans
Off-Grid	7.4	10	Higher	Multilateral and bilateral guarantees and concessi-onal loans	Private sector, Government budget
			Lower	Multilateral and bilateral concess-ional loans and grants	Government budget

Source: IEA World Economic Outlook 2011.

From table 3.1 above, it is clear that public sector funding (subsidies, budget and equity investment) is crucial in providing on-grid electrification for the lower energy expenditure households. A critical component of the financing model adopted by Vietnam for instance, is a substantial cost sharing arrangement between the local government and the local communities where electrification projects are carried out. This has proved to be very successful in providing sustainable rural electrification[44]. Nigeria

[44] Ibid note 44

can take a leaf out of this experience with slight modifications to suite its peculiarities.
Some government –owned utilities also embark on cross-subsidies whereby profits derived from major high expenditure customers are used to subsidize the lower energy expenditure bracket. This sort of arrangement was pursued by Eskom in South Africa, which is the government–owned utility, although, the practice was not sustainable in the long run.

3.4.2 Financing Rural Electrification (mini-grid)

Mini-grids especially small-hydro and diesel, have been playing a very critical role in the rural electrification drives of most best practice countries such as China, Mali and Sri-Lanka (World Bank, 2008). Although mini-grid projects are usually started by government initiatives, the IEA (2011) estimates that there is an additional annual investment requirement of $12 billion under the 'energy for all' scenario from 2010-2030.

Various mini-grid technology projects are being embarked upon by different countries across the globe. Eight West African countries are currently benefitting from a Global Environmental Fund (GEF) energy programme on mini-grids that are powered by renewable energy. These types of renewable energy powered mini-grids are also becoming popular in Thailand according to Phuangpornpitak et al. (2005), and are now more competitive when compared with diesel-generated mini-grids (ARE, 2011a).

Other arrangements whereby Governments partner with the private sector under a PPP abound: In Laos for instance, ARE (2011b) reported that a hybrid mini-grid (hydro, diesel and solar PV) that would serve over a 100 rural households has been established. Here, the government would fund the capital assets, while the private sector will fund the operating costs. This sort of PPP is yet to be adequately explored in Nigeria for rural electrification.

There are varied financing and technical options for mini-grid systems. Running mini-grids (especially diesel-based systems) could be based on cost recovery with a guaranteed margin, to make it attractive for commercial finance from the private sector. For smaller mini-grid projects, subsidies on output could be used to aid the private sector. Appropriate and targeted subsidies such as auction for concessions mixed with output-related subsidies, could give some incentives to concessionaires to complete stipulated connections.

Viability gap funding will be applied in this case, where interested electricity companies bid for their respective required value of subsidies based on a prearranged rate for a number of electricity connections. In principle, electricity providers are allowed to choose the technology options and solutions that are cost-effective under such auctions, and they are not tied down to particular technology types[45]. This model can be replicated in Nigeria to accelerate electricity access in rural areas.

Funding for the take-off of such auction and subsidy schemes could be gotten from grants and loans provided to governments by bilateral and multilateral sources. Senegal benefitted from such grants from GEF and International Development Association (IDA) in 2006 as reported by (GPOBA, 2007). The same support could be extended to programmes targeted at end-users, where credit is provided to rural customers to cover connection charges through the banks or concessionaire. The Electric Power Corporation of Ethiopia is an example of such beneficiary of credits from IDA and GEF[46].

For low energy expenditure households, it is critical for governments to initiate financing co-operatives as well as embark on partnerships with the private sector, to enhance a sustainable financing model for min-grid

[45] Global Partnership on Output-Based Aid (GPOBA), "*Output-Based Aid in Senegal- Designing Technology-Neutral Concessions for Rural Electrification*", OB Approaches Note No.14, GPOBA, Washington D.C. (2007) athttp://www.gpoba.org/gpoba/sites/gpoba.org/files/OBApproaches14_SenegalElectric_0.pdf (last visited on the 13th of February, 2012).

[46] GPOBA, "Output-Based Aid in Ethiopia: Dealing with the 'Last Mile' Paradox in Rural Electrification", OBApproaches Note No. 27, GPOBA, Washington D.C. (2009) at http://www.gpoba.org/gpoba/node/313 (last visited on the 13th of February, 2012).

electrification systems. Examples of such partnerships and co-operatives exist in Nepal and Bangladesh (Yadoo and Cruickshank, 2010).

However, while the examples listed above presents good opportunities for cross-learning for other developing countries in terms of financing options for mini-grid systems, decisions leading to the choice of grid, mini-grid or off-grid to use, should be based on certain critical factors such as topography, grid penetration, costs, and other demographic peculiarities of the country.

3.4.3 Financing Rural Electrification (off-grid)

Bhattacharyya, S.C. (2013) in his review of off-grid electrification experience outside South Asia, took a look at various technology choices being currently used in different countries, and adopted a broad coverage of technologies to include mini-grid, stand alone, renewable and conventional technologies. He noted that it has been difficult in tracing the progress of the use of off-grid systems due to its dispersed, small-scale and demand driven nature of implementation, as well as bias in data and literature as seen in the type of reporting which are usually project-implementation and technical based.

Further, he observed that while conventional and renewable energies can both serve in off-grid systems, solar photovoltaic (PV) and Solar Home Systems (SHS) appear to be preferable technologies used in rural areas. He also reported that other forms of energy technologies gaining wide spread acceptability and use in rural areas are; Biogas, small hydro and pico-PV, and that most off-grid projects are often donor-supported or led. He advocated for the Chinese rural electrification experience as a model that other developing countries should strive to replicate due to its tremendous success.

In the energy for all case of IEA (2011), an estimated annual additional investment of $7 billion is required for off-grid electricity till 2030. Generally, the private sector is disenchanted about investing in off-grid power systems, as it is viewed as unattractive for investments. Thus, alternative financing mechanisms are adopted in the meantime for both high energy expenditure households and their low energy expenditure counterpart. Capacity enhancement programmes for dealers in SHS and lanterns for instance to extend financing to end-users, will go a long way. The Philippines (UNEP, 2007), and Kenya[47] are good examples of countries that have adopted this financing model successfully.

Microfinance institutions or local banks could also be supported with funds from Government or Multilateral and Bilateral institutions to be handed down to end-users as loans, and where they are not available, agricultural co-operatives could serve the purpose. Examples of this are the Solar Loan Programme of UNEP in India[48], as well as the Rural Energy Foundation supported by Netherlands' government in many African countries (Morris et al., 2007). Output-based subsidies could also be funded with the same support from government and concessional funds in some countries, while a combination of various sources of financing at different points in the project lifespan is also in order.

Given the challenging nature of raising finance for off-grid electrification especially for the low energy expenditure households, it is imperative for governments of various developing countries to collaborate with multilateral and bilateral organizations to stem this tide. A good example of a workable and sustainable solution is World Bank and GEF pioneered solar marketing packages in the Philippines, Tanzania and Zambia.

[47] Yadoo, A. and H. Cruickshank, "The Value of Co-operatives in Rural Electrification", Energy Policy, Vol. 38, Issue 6, Elsevier, Amsterdam, pp. 2 941-2 947 (2010)

[48] UNEP (United Nations Environmental Programme), Financing Mechanisms and Public/Private Risk Sharing Instruments for Financing Small-Scale Renewable Energy Equipment and Projects at http://www.unep.fr/energy/activities/frm/pdf/SSRE.pdf (last visited on the 14th of February, 2012).

Under this programme, host governments support off-grid electrification by providing incentives for dealers of PV systems and giving them contracts to install and maintain solar photovoltaic systems to public buildings such as clinics, schools and public offices. In addition, subsidies are provided for installations extended to non-public buildings within the concession area as part of the contract (OECD/IEA, 2011). So many other solutions that involve financing end-users such as the fee-for-service scheme adopted in the Eastern province of Zambia[49] represent a veritable option as well.

Mainali and Silveira (2010), looked at how off-grid rural electrification in Nepal have been funded from the point of view of the impact of subsidy policies on the RE market. The study found that while there has been an increase in awareness in rural electrification amongst the rural populace in Nepal, coupled with the willingness to access and pay for these technologies, there exists, the challenge of an overwhelming gap between the cost of electrifying these communities and ability to pay by the rural dwellers.

The methodology employed here involved the use of data from the data bureau of Nepal, as well as a direct survey carried out amongst private installations and supply companies. They concluded that for rural electrification to be expanded and successful, the gap between the cost of the technologies and affordability has to be bridged, as well as innovative ways to finance projects in a sustainable manner such as subsidies, credit and equity, should be looked into critically[50].

Palit and Chaurey (2013), reviewed off-grid projects of best practices in South Asia and reported that while there has been an increasing mix in off-grid technologies used in rural South Asia, solar PV, mini/micro hydro and biomass gasifiers have been trending. They also observed that most of the off-grid projects were driven by grants and donor agencies, most of which

[49]Lemaire, X., *Fee-for-service companies for rural electrification with photovoltaic systems: The case of Zambia* at http://www.sciencedirect.com/science/article/pii/S0973082609000052
[50]Mainali B. and Silveira S. Financing Off-grid Rural Electrification: Country Case Nepal, Energy Journal 36 (2011) pp. 2194-2201

especially in Sri-Lanka are clean energies. More so, there have been failure rates recorded in a large part of the projects mostly due to the emphasis placed on the technical installations as opposed to taking issues of sustainability and long-term use into cognisance. They concluded that for solar PV to succeed and gain further inroads into the rural areas, technical support and spare parts should be made available at all times, while the collection of fees should be done by a third party rather than the community, and maintenance of the PV systems should not rest squarely on users only.

Thus, for an off-grid project to be financially sustainable, it has to be carefully packaged in such a way that all stakeholders (government, financiers, consumers, service providers) would benefit from it. The government, while aiming to supply the rural areas with off-grid solutions, should also look at how the demand side challenges such as income levels of consumers in rural areas, productive activities and building a vibrant rural economy, can be tackled holistically. The government would also need to drive the process of packaging the off-grid project; financing options, approaching financiers, identifying key stakeholders, subsidies and other incentives and regulation.

3.5 Financing Sources and Mechanisms

According to UNDP (2008), most energy systems are highly capital-intensive; which makes the provision of appropriate financing very necessary for private sector investments in rural energy projects to thrive in developing countries. Financing is generally categorised into three in the private sector; on the business finance side, equity and debt finance, and on the demand side, there is the consumer financing to enhance affordability. Other sources of financing according to IEA (2011) includes: bilateral/multilateral development sources and governments of developing countries.

3.5.1 Debt Finance

Various barriers militating against the accessibility of debt financing for rural electrification in developing countries of Sub-Saharan Africa have been enumerated in IED-DFID (2013). They include: Lack of long term loans for rural electrification projects, as most of these projects have life-cycles of over 10 years and most local banks find it difficult to provide debt financing; Lack of rural electrification projects financing experience by most African banks, and the inability of rural electrification project developers to provide reasonable guarantees demanded by banks.

Further, most developing countries have weak capital markets, which has negative implications for the development of rural energy projects that are characteristically capital intensive. Scarcely available finances in developing countries usually go with low debt-to-equity ratios, high interest rates and short maturities which lead to an increase in capital costs as well as electricity price produced per kWh especially in renewable energy projects, thereby discouraging its investment[51].

The problem of lack of capacity of rural dwellers to pay for the service rendered by this project, and the lack of clarity on the cash-flow of the project also constitutes a major barrier to accessing loans for rural electrification projects. It is therefore necessary that investors in rural energy not only allow for long term financing and some social benefits as regards energy security and the environment provided by RE and embedded in interest rates, but are also 'patient'. This would make rural energy projects more competitive as well as reduce costs per kWh.

3.5.2 Equity Finance

Energy projects are generally capital-intensive, and most rural electrification projects have high initial capital investments, which is usually beyond the

[51] UNDP, Financing Options for Renewable Energy: Country Experiences 2008 at http://asia-pacific.undp.org/practices/energy_env/rep-por/documents/FinancingOptionsRenewableEnergy.pdf , last visited on 17th of January 2012.

investor's capability to finance by equity (IED-DFID 2013). Tax regimes in most Sub-Sahara African countries are also considered not to be friendly towards equity financing. The long life-cycle of rural electrification projects and their relatively small sizes, discourage private equity funds from investing. The prevalence of vague power purchase agreements for larger renewable energy projects, lack of financing from local banks, high interest rates and the challenge of greater risks have also contributed to low levels of private investments in RE over the years.

Further, most investors in various developing countries do not regard investments in rural electrification as a conventional investment exercise, while the interested investors find it difficult to access enough funds to expand their activities (UNDP 2008). More so, expected rate of return, which is a critical factor for private investors also constitute an issue for equity financing. While some private investors may be satisfied with a return of between 6%-8%, others may not be interested, and look out for investments with return rates as high as 20% (IED-DFID 2013).

An example of a venture capital fund that is currently tending towards the provision of the aforementioned 'patient' capital that is needed for RE investments is the US based E+Co. The organisation operates in Asia, Latin America and Africa and provides equity investments or loans as well as business development services to investors in clean energy technologies. The fund is supported by the World Bank, Dutch Ministry of Foreign affairs and Hivos Foundation. A couple of other organisations such as the IFC, Asian Development Bank (ADB) and Winrock International also make funds available for RE projects. More of these types of organisations are needed to create the synergy and funds needed to drive RE projects and development in rural areas.

Thus, for rural electrification projects to attract equity financing, mechanisms such as low cost of capital, adequate guarantees, long term loans, proper risk sharing and conducive investment environment have to be put in place, and driven by a committed government.

3.5.3 End user Finance

Various arrangements ranging from leasing, loans from microcredit/finance organizations, instalment payment plans provided by retailers and a host of others, all form the crux of end-user finance at rural community and household levels. The importance and role of end-users financing especially in scaling-up RETs and increasing rural access to such technologies cannot be overemphasized (UNDP, 2008).

This type of financing is fast gaining grounds in most developing markets as banks give out loans for various appliances in the household spanning cars, motorcycles and homes in majorly urban cities of salary earning workers. However, RET financing is yet to make the list of items for consumer financing of mainstream banks, even if few microfinance banks and institutions are doing exceptionally well in this regard at the rural levels especially in biogas or solar home systems (SHS). This disparity is largely due to the lack of specific management expertise by retailers often required by credit operators, which has constituted a major drain on working capital.

The World bank/GEF funds in countries like Bangladesh and Sri-Lanka has availed organisations like Grameen Shakti and BRAC as well as SEEDS lines of credit to embark on RE projects such as solar home systems (UNDP, 2008). Triodos Bank of Netherlands is another bank that is active in providing loans to Microfinance organisations for onward lending to customers for various RETs systems. Uganda's Development Bank with Support from Shell, India's Syndicate Bank and Canary Bank are also examples.

The UNDP report on financing options for RE of 2008 also suggests credit enhancement initiatives could help banks to form new consumer loan base in markets where RE already exists on a commercial cash-sales level. This could be done by enhancing demand for such loans, reducing risks for the finance institutions, giving government guarantees/ collateral assistance, increasing loan durations, depending on the circumstance.

Even with the very strong evidence provided by microcredit disbursements to the rural poor and how it has enhanced commercialization of RETs, just a handful of case studies can be pointed at, where the poor rural dwellers had been able to enhance their access to energy via financing. In most successful cases, the combination of financing instruments with income earning/generating enterprises have provided a more sustainable and improved energy access to the poor. An example of one such successful case includes the provision of solar lanterns at a daily fee to microenterprises by a rural cooperative society called Wahan Dharak in Maharastha, India[52]. By and large, microfinance organisations present a veritable platform for scaling up as a fundamental strategy for increasing access to the rural poor.

3.5.4 Carbon Finance

New revenues accruing from the emerging carbon market and the Clean Development Mechanisms (CDM) have given RE projects a financial boost, and the rise in carbon price also portends greater future impacts. Here, revenue is derived from the sale of carbon credits through voluntary mechanisms and the CDM[53]. Initially, the CDM largely covered projects to reduce the emission of greenhouse gases (GHGs) such as nitrous oxide, methane and hydro fluorocarbons found in agriculture, landfills and industrial processes respectively.

However, RE projects, especially the large grid-connected ones are gradually being reflected in the CDM. In the CDM pipeline of 2008, RE projects had a share of 39% of total projects and a share of 41% in total carbon reductions[54]. In the same period, in terms of RE-based Certified Emission

[52] www.nrel.gov/villagepower/vpconference/vp2000/vp2000_conference/bundled_pavankumar_siddhi.pdf
[53] Supra note 1
[54] *Supra* note 14

Reductions (CERs), the CDM pipeline consisted of wind (8%), biomass (6%), hydropower (24%), biogas (2%) and geothermal (1%), while solar energy's CERs were negligible. It is hoped that this would also extend to rural electrification especially for off-grid RE projects.

According to OECD/IEA World Energy Outlook (2011), prior to the global financial crisis of the late 2000s, the value of carbon credits produced from new CDM projects was around $7 billion yearly. Sub-Saharan Africa presents a huge potential for raising new CDM revenue given the estimated energy access projects to be carried out within the region (150GW electricity generation), which would cost $200billion. The World Bank (2011) estimated that these projects could generate as much as $98 billion in CDM revenue using the carbon offset rate of $10 per tonne of CO_2. However, in January 2014, the European carbon price was just slightly below EUR 5 per tonne, and it is anticipated to rise by over 50% to EUR 7.5 per tonne before the end of 2014[55]. This anticipated rise is attributed to plans to backload auctions of carbon allowances of the European Union (approved by the European Parliament late 2013) that should have normally taken place within 2014-2016, to a further date in the decade.

A couple of barriers have however, impeded the development of CDM for RE projects in host countries, such as the risks associated with feasibility studies and initial costs and investments in new projects, lack of capacity to generate adequate emission reduction units to attract buyers who usually buy at least 30,000 tons of CO_2 yearly as opposed to the 0.250 tons of CO_2 typically produced by a solar home system, which implies that a project of 120,000 SHS is needed to make it attractive for a CDM project. The lack of experience on the part of entrepreneurs in CDM financing as well as the lack of clarity of rules and conditions also constitute major barriers (UNDP, 2008). Therefore, most poor countries have not benefitted much from the carbon finance market in terms of financing rural electrification.

[55] See http://about.bnef.com/press-releases/value-of-the-worlds-carbon-markets-to-rise-again-in-2014/ (last visited on 23rd of March, 2014)

3.5.5 Institutions and Funds Dedicated for RET investment and Promotion

RE funds that give out low-interest loans, directly carry out finance investments and/or facilitate the RE markets in other ways have been established in some countries, provinces or states. The public health funds in 14 states of US is the largest of such funds, and are often administered to RE and energy efficiency via surcharges on electricity sales and a couple of other sources (UNDP, 2008). These 14 public health funds were established between 1997 and 2001 and have been able to save and dispense at least 300 million USD yearly on RE, with an expectation that they will save up to 4 billion USD for RE by 2012.

The establishment of some specialized funds and institutions committed primarily to promote RE is making a difference in countries like India and Nepal. According to UNDP (2008), the India Renewable Energy Development Agency (IREDA) has been very instrumental in bringing about substantial investments in various RE projects in India, thereby re-positioning the RE sector in India towards commercialization.

Nepal's Alternative Energy Promotion Centre (AEPC) established as an independent government agency in 1996 has also been very useful in developing and promoting RETs, especially in the area of subsidy disbursement, monitoring, research and human resource development, they get technical and organizational support from the Danish International Development Agency (DANIDA) in solar PV, ICS and micro-hydropower development. The activities of AEPC has led to increased private sector involvement in RE development, as it serves as a one-stop shop for all the stakeholders interested in the RE sector.

Examples of other countries that have followed suit in this regard are Malaysia which has set up MESITA, Cambodia with the Rural Electrification Fund (REF), Nepal's Power Development Fund (PDF); Biogas Credit Fund

(BCF) and Thailand's ENCON fund. All of these funds aim at promoting and developing rural electrification, energy conservation and renewable energy.

3.5.6 Bilateral and Multilateral Institutions

Development assistance (grants, investment guarantees and concessional loans) offered by the 24 OECD countries under the Development Assistance Committee, constitutes an example of bilateral sources of funding energy projects. The World Bank, OPEC Fund for International Development (OFID), Regional Development Banks and SREP, are examples of multilateral sources of financing for energy projects. The main instrument employed by the World Bank for instance for energy projects, includes; credits gotten from International Development Association (IDA), grants, carbon funds and special funds from GEF. Other international institutions that have been supportive of energy access projects in various ways include; International Bank for Reconstruction and Development (IBRD), International Financial Corporation (IFC), UNDP, UNEP, Multilateral Investment Guarantee Agency (MIGA) and the Guarantee Institution for Export Credit (GIEK) of Norway (IEA, 2011). Table 3.2 below summarizes various financing mechanisms and instruments for rural electrification in the World.

Table 3.2: Financing Mechanisms and Instruments

	Grants and credits	Concessionary loans	Market-Rate Loans	Credit Line For On-lending	Partial Credit Guarantees	Political Risk insurance	Equity	Quasi-equity	Carbon Financing	Subsidy/cross subsidy	Feed-in tariff	Technical assistance
Multilateral Development banks	X	X	X	X	X	X	X	X	X			X
Bilateral Development agencies	X	X	X	X					X			X
Export-import banks and Guarantee agencies			X			X						X
Developing countries' governments	X	X					X	X		X	X	
State-owned utilities							X			X	X	
National development banks		X	X	X	X							X
Rural Energy agencies and funds	X									X		X
Foundations	X						X		X			
Microfinance			X									
Local banks			X									
International investment banks			X					X	X			
Investment funds							X		X			
Private investors							X		X			X

Source: IEA World Economic Outlook 2011.

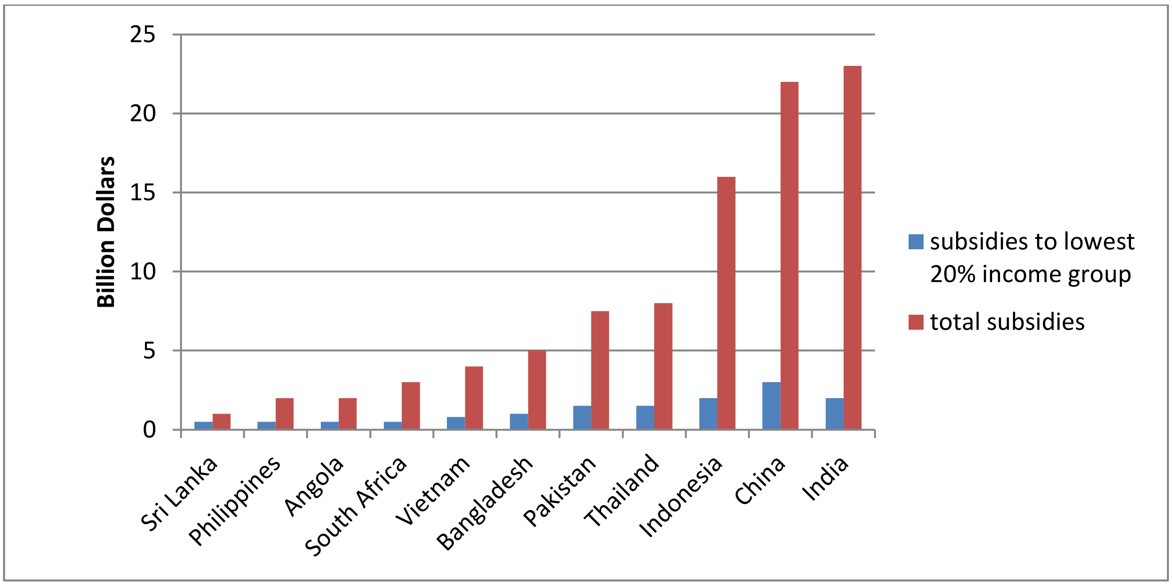
3.5.7 Governments of Developing countries source

Through special purpose vehicles such as rural energy agencies, central banks etc., grants and loans targeted at increasing access to rural energy are disbursed by various governments of developing countries, to the rural areas. Other ways embarked upon by governments of developing countries to finance rural energy include; targeted subsidies, concessional guarantees and feed-in tariffs as shown in (table 3.2) above. Internally generated funds of state-owned electricity utilities of developing countries are usually used to finance grid expansion projects, where such utilities are efficiently and independently run (IEA, 2011).

However, in most cases these state-owned utilities are plagued with corruption, political interferences and inefficiencies, whereby, government entities fail to pay utility bills and there are no ways to sanction them[56]. Non-payment issues could be addressed by the use of pre-payment meters as successfully done in South-Africa, while subsidies should be funded by governments' yearly budget or donor funds. Emphasis should be laid on focusing these subsidies at those that need them the most though, as unfortunately, the issue of not targeting the poor for subsidies has led to abuse of such programmes.

Figure 3.2 below provides information on rural energy subsidies given to the lowest 20% income group against total subsidies in some selected countries in the World:

Figure 3.2: Subsidies on Fossil-fuels in selected countries (2010)



Source: IEA World Economic Outlook 2011.

[56] Supra note 14

3.5.8 Other Innovative Financial Mechanisms

H. Liming (2008) took a comparative look at financing rural renewable energy between China and India, and pointed out the need for more innovative mechanisms for financing rural renewable energy projects and expanding its use on a large-scale commercial basis. Amongst some of his recommendations were:

- The intensification of mechanisms that combine government and community financing as operated in India;
- India's decentralised solar system based on a market-oriented financial and institutional model;
- Combining public sector financing with CDM for wind-power development (India);
- The use of market regulation bidding process with government finance to scale-up renewable village power practised in China;
- Utilizing CDM to finance renewable energy for rural areas as successfully experienced for the first time in China;
- Using economic incentives to finance landfill gas utilization (China);
- Using financial intermediaries to commercialise solar hot water systems such the 'FI scheme' of India;
- Post-subsidy regime development of market for solar lanterns in India and developing a financial model for solar pumping systems that is sustainable (India)[57].

3.5.9 The Role of Public-Private Investments and PPP

Various examples of successful cases of public-private partnerships (PPP) in various sectors are widely reported in Literature. In the RE sector in various regions, some examples of successful projects being financed in this way are also available. India's biogas initiative is one of such examples (UNDP, 2008), here, the private sector, government and civil society went into

[57]RISPO, Innovative financing mechanisms for renewable energy development, at http://www.iges.or.jp/APEIS/RISPO/p_report_2nd/06_3_2_1_innovative_financing_for_renewable_energy.pdf (last visited on the 22nd of February, 2012)

collaboration to design a programme called the National Project on Biogas Development (NPBD), targeted at the market of the rural poor, with specific technology and investment subsidy for end-users. A subsidy range of 25% to 50% are given to families that opt for the use of biogas plants, and the technology is being developed and promoted in rural areas based on the partnership between government, private investors and civil organisations, which has boosted the diffusion of biogas technology use to the rural areas in no small measure.

The Energy Services Delivery Programme supported by the World Bank and the Sri Lankan government between 1997 and 2002 is another example of a successful PPP RE project financing arrangement. Here, medium and long term loans were provided to MF institutions, private enterprises, community cooperatives and NGOs to develop SHS, off-grid technologies, mini-hydropower of around 10 MW, Demand Side Management (DSM) and energy efficiency investments and projects (UNDP, 2008). The success of this initiative led to a further collaboration by the World Bank and Sri Lankan government to establish the RERED which amongst other RE support drive/policies, emphasizes the economic and social development of the rural areas.

3.5.10 Conclusion on Private and Public Involvement in RET Dissemination

The effectiveness of the use of public resources can be seen especially as regards leveraging quality e.g. through minimal warranties, quality standards etc.

The use of public resources, be it via government or NGO, in synthesizing RE development into a broader rural developmental drive is very critical as was done in the micro-hydropower programme of UNDP’s Rural Energy Development, which does not only provide the needed social infrastructure for the rural communities, but also goes on to present a platform for entrenching democratic values in decision making processes, promoting gender equality, and enhancing technical know-how and managerial skills (UNDP, 2008).

Experiences from increasing number of various developing countries show that specifically tailored and targeted government policies towards promoting and developing RE has the potential to not only commercialize RE in the rural areas, but also stimulate economic activities and provide jobs beyond what a centralised conventional fuel plants can achieve.

Although at high expense of the public purse, and the tendency to be limited to equipment installation without recourse to sustainable operations, a well-structured, targeted and transparent subsidy programme has proved to be very productive in reaching the rural poor.

3.6 Integrating Rural Renewable Energy, Private Investments and Rural Economic Development

Profitability is the motive in any private sector investment, and most rational investors would put their money in the most profitable markets first[58]. However, with the support of Government, NGOs and donor agencies, the private sector can be spurred into embarking on targeted energy initiatives that would address rural energy challenge and generate economic activities/employment on one hand, while also allowing for fair returns for investors on the other hand.

It is therefore imperative to explicitly design a policy that would support the linkage of Rural Electrification applications to higher incomes and enhanced living conditions of the rural poor. Based on research and Experience, the UNDP in collaboration with ESMAP have been able to make some recommendations that have proved to be very effective in enhancing such linkages. They are described below.

[58] http://www.unglobalcompact.org/AboutTheGC/index.html

3.6.1 Formulating Targeted and Effective Subsidies

Subsidies, as presently applied in most developing countries are not only wasteful, inappropriate and ineffective, but also do not reach the intended set of poor people in most cases. Thus, an effective subsidy policy that is targeted at the poor, well designed, performance-based, with a reasonable time-span and economically rational is critical to attracting private investments. Furthermore, subsidies should preferably be administered on lump sum capital costs, rather than on operational costs, as there is a degree of uncertainty in the long-term availability of funds for operational costs.

3.6.2 Enhancing Innovation

Initial researches and studies leading up to designing a new project or technology, usually involve huge costs. This stage has not really been given adequate support especially from donor agencies and financial institutions, as it is considered outside their normal activities. So far, trust funds and GEF support is being used to make-up for such preliminary stages of World Bank projects and such partnerships should be promoted and enhanced.

3.6.3 Strengthening the link between energy services and other sectors.

There is a critical need to blend rural energy services with small and medium enterprises (SME) advancement, income generating activities, telecommunications, water supply initiatives, health and education. Various examples can be found in different countries whereby RE-powered equipment such as tailor's sewing and staples grinding machines, as well as telecommunications booths using solar PV are provided for rural microenterprises.

Prevalent in most developing countries is the lack of adequate knowledge on integrating rural energy infrastructure into other critical sectors such as water, agriculture, health, education and other like projects. Development specialists have to put in place a wide range of coalitions amongst various actors and integrators to achieve effective inter-sectoral linkages that would generate the needed economic activities for income and welfare improvements. These critical integrators are described below.

3.6.3.1 Microfinance Banks/Institutions (MFI)

The role of MFIs in integrating rural energy services with other sectors, and reducing poverty has gained worldwide recognition. Millions of poor people and microenterprises across the globe have benefitted from loans given out by MFIs. The very nature of their operations, which involves constant interaction with microenterprises and the poor, gives them a unique insight and knowledge into how to best link energy services with income generating activities for the rural poor. Although the MFIs have gradually began to provide credit facilities to the rural community to invest in rural renewable energy services, there is need to also invest heavily into increasing the capacity of linking energy into a wider range of income-generating and productive activities.

3.6.3.2 SMEs-Support Agencies

A host of development organisations such as the International Labour Organisation (ILO) and United Nations Industrial Development Organisation (UNIDO) donor organisations, development banks and Non-Governmental Organisations (NGOs) support SMEs to enhance their productivity. Energy options such as biomass cogeneration, solar, wind and hydropower can be fused into this package in a systematic way, to boost the long term sustainability of these SMEs.

3.6.3.3 Using RE to promote Microenterprises

An extensive system of multi-function platforms has been established with loans given out to rural poor and women by microcredit organisations in some developing countries. This enables them to increase their productivity and incomes. The UNDP supports some of such initiatives in West Africa, Mali to be specific, where rural women are able to increase their agricultural productivity, reduce work hours, and increase incomes. The initiative also afforded a small rural farmers' coconut cooperative in the Philippines to use electricity produced from biomass cogeneration to increase coconuts processing into high-value finished goods, while employing over 120 poor rural dwellers. Thus, various multi-function platforms that have the potential to be replicated and diffused should be supported and promoted especially by development institutions such as the UNDP in other developing countries.

3.6.3.4 The Role of NGOs

Many NGOs, especially small localized ones, are highly experienced and knowledgeable in handling rural affairs. This is a capacity they have achieved over time as they interact directly with local communities in various aspects of community development. Empowering and engaging these NGOs in developmental projects will go a long way in complementing efforts of lending institutions and international donor organisations to integrate energy services into income generating activities.

3.6.3.5 Vendors of RE products

Another crucial agent of integrating energy products with other sectors are the vendors of RETs. A substantial number of RETs private sector vendors have erupted in various countries as a result of expansion in the market for RETs. They represent an important asset as they interact with consumers and development institutions that purchase energy systems on a regular basis. They have acquired skills and valuable knowledge in different sectors such as info-tech, agriculture and tourism that could be tapped into by private investors and development organisations. Thus, the vendors could be supported to enhance their packages to a broader range, which would expand the use with which the RETs are applied to, thereby, increasing productivity and income generation.

3.6.3.6 Community-driven energy projects

Energy projects driven by local communities such as small/mini hydropower projects, gives the platform for further developments that fuses energy output to productive activities and income generation. Apart from meeting the energy needs of the community, such community driven energy projects also enhance social welfare conditions especially in health, education and environment. Thus, it is imperative to accelerate the diffusion and scale-up of such initiatives to different regions. Two good examples of community-based energy initiative in Asia and Pacific region are Nepal's Renewable Energy Development Programme and Pakistan's Aga Khan Rural Support Programme.

3.6.3.7 Governments of different tiers

Governments at different levels, from central to state and local tiers, all have critical stakes in promoting and ensuring effective integration of RETs in their developmental programmes, especially, in areas of health, agriculture and education. Policies and enabling environment to attract investments into RETs as a platform to integrate with other sectors, is also under the purview of governance at different levels.

3.6.3.8 Development institutions and Development Banks

Various development organisations such as the UN and its agencies (FAO, UNIDO, ILO, UNICEF, WHO, UNESCO) have embarked on various projects across different sectors in almost all the regions of the world. Integrating these projects with RETs and widening its scope to encompass training, skill acquisition and information diffusion, will go a long way in enhancing the linkage between energy and development drives. Development banks on the other hand, such as ADB and World Bank have over the years invested substantially into various developmental projects, especially in the rural areas of developing countries. These projects, which span different sectors such as agriculture, industry and SMEs, have been gaining expansion to allow integration between the RETs and other non-energy projects.

3.6.4 Enhancing the availability and quality of information

The World Bank (2004), was unequivocal in pointing out the importance of having better information on RE technologies/market and energy efficiency, readily available. This makes it easier for those private investors interested in investing in the RE sector, as well as financiers, households and communities, governments and other relevant stakeholders to make informed judgements and decisions.

3.6.5 Broadening the involvements of NGOs

NGOs involved in various community services related to energy could be strengthened, expanded to cover more regions and their capacities deepened to include training of old staff members, and recruitment of new ones. Guidelines of best practices as regards linking modern energy services with rural economic development and community services could also be set for these NGOs. Incentives and awards should also be used to encourage these NGOs doing well.

3.6.6 Training and building of capacity

In order to establish a strong and sustainable foundation for local capacity to broaden energy services, there is need for the local community to embrace training and capacity building activities. Thus, support in providing the enabling environment required to build this capacity and sustain it to allow for scaling up RE use, is very important.

3.6.7 International collaborations fostering RE for poverty reduction

There are a couple of international partnerships and co-operation that work to promote RETs towards integrating it with other non-energy sectors, so as to alleviate poverty and empowerment of women and rural dwellers. Examples of such partnerships and organizations are the Global Village Energy Partnership (GVEP), which serves as a spring-board for broadening investments in modern energy services for economic and social development in rural areas, and the Global Network on Energy for Sustainable Development, which is a brain-child of UNEP and promotes knowledge network and partnerships in developing countries as regards energy. Establishing more of these international alliances that promote energy integration with other sectors to reduce poverty could accelerate the scale up of modern energy use in rural areas, reduce poverty and enhance gender equality.

3.6.8 Promoting innovation in RE utilization

Incentives and awards could be used to encourage innovations and broader enlightenment about the most effective models for linking energy with poverty reduction. Examples of such awards are the UK's Ashden Trust and the World Bank's development market place, which motivate and reward innovations in effective small-scale development projects. However, awards for energy-based projects constitute a small percentage of these awards, there is need to increase this percentage and strive to replicate these programmes in different developing countries.

3.6.9 Mechanisms for scaling up rural energy access by the World Bank

The Energy Unit of the World Bank has over the years built on past experiences to design an energy access roadmap of models that are scalable and easily replicated. A guidebook for scaling up access to rural energy has been developed and is available online at the GVEP website. It covers all aspects of energy; Renewable and non-renewable energy options, grid and off-grid power systems.

3.7 Review of Methodologies for Analysing Rural Electricity Supply

Bhattacharyya S.C. (2011) provided an extensive review of various methodologies and approaches that have been used in analysing off-grid electricity supply. He found that most literature focused on techno-economic and environmental aspects of the problem, and are grouped into three major approaches: a) Technical Analysis b) Optimisation Tools, and c) Practice-oriented. He also listed a number of choices that can be identified as alternative methodological options for analysing rural electrification supply as follows:

1. A spreadsheet-based tool that delivers a serial analysis of the four scopes retained in the project proposal;
2. An optimisation tool to identify least-cost options, accompanied by a routine to incorporate regulatory and social issues;

3. A Multi-criteria decision making tool;
4. A participatory systems approach
5. A combination of the above-mentioned options on a case-by-case basis.

This subsection provides a brief review of these.

For the techno-economic analysis approach, the focus is usually on the technical design of the system, and an economic analysis of its cost effectiveness in various case studies. Examples of literature on this methodology are: Bernal-Agustin and Dufo-Lopez (2009), who considered hybrid renewable energy systems; Sinha and Kandpal (1991) who did a comparative analysis between electricity supply through grid and off-grid systems in rural India; Reddy et al (1990) posited that the level of energy services provided should be used as the indicator for development rather than the magnitude of energy use; Siyambalapitiya et al (1991) analysed grid-connected electrification options in rural areas of developing countries and found that its main problem is the low load factor of rural energy demand.

Bates and Wilshaw (1999) provided the barriers, status and government policies of solar PV electrification; Rabbah (2005) looked at the practicality of implementing solar systems in Kenya; Schmidt and Hoffman (2004) did an analysis of replacing diesel with PV system in Brazil; Gulli (2006) did a social cost-benefit analysis of the commercial and residential sectors; Chakraborti and Chakraborty (2002) presented the case of Sagar Dweep-India's solar PV; Rana et al (1998) looked at the best combination of energy for rural application in India; while Kumar et al (2003) analysed the optimal cost and plant size for biomass in Western Canada.

For the Analytical Approach, we have optimisation tools such as HOMER (Hybrid Optimisation Model for Electric Renewables) developed by the National Renewable Energy Laboratory in the USA, which has been pre-dominantly used by many authors for optimisation and simulation of different technologies (PV, hydro, boilers, fuel cells, wind, etc.). Authors who have used this tool include; Zoulias and Lymberouspoulous (2007), Demiroren and Yilmaz (2010), Kamel and Dahl (2005), Khan and Iqbal (2005), Turkey and Telli (2011), Dalton et al (2009) and (2008), Lau et al (2010), Setiawan et al (2009), Nfah et al (2008), Weis and Ilinca (2008), Himri et al (2008), Bakele and Palm (2010), Nandi and Ghosh (2011), Shaahid and El-Amin (2009) and Shaahid and Elhadidy (2007 & 2008).

Other specific software tools used are Hybrid Optimisation by Genetic Algorithms (HOGA) developed by the University of Zaragoza in Spain, HYBRID2, and RETScreen. Some other techniques includes: Linear programming, dynamic programming, stochastic programming, Integer programming, Multi-objective programming, Separable programming, Quadratic programming and Goal programming. Indicator based approaches have also been employed in literature for analysing rural energy supply; they include the use of sustainability indicators, levelized costs and weighted scores.

The Multi-criteria decision making method (MCDM) allows a decision-maker to have options and order them accordingly, as it captures the multiple dimensions of a policy or project that may be inconsistent with each other. They include the Analytical Hierarchy Process (AHP) and Multi-criteria Decision Making for Renewable Energy Sources (MCDM-RES).

The System Analysis Approach incorporates information feedback structures in systems and analyses them quantitatively (Forrester, 1961, Coyle, 1997). For practice-oriented literature for decentralised rural electrification supply analysis, there is a host of research done in this area. See ESMAP (2001), CEEP (2001), Cabraal et al. (1996) and World Bank (2008).

3.8 Financing Rural Electrification: Country Experiences

An extensive review of financing rural electrification in various countries has been carried-out by Bhattacharyya (2013) in his book-Rural Electrification through Decentralised Off-grid Systems in Developing Countries, which was very useful for this research. This subsection summarises some of the findings as regards financing and lessons to learn from the experiences of a few countries:

3.8.1 China

China is a good example of a country that has been largely successful in its rural electrification pursuit. China has passed through three distinct phases central Planning, market-driven phase, and dynamic market economy era[59], spanning 1949 till date. China was able to employ a number of technologies such as hydropower, coal resources, biogas/biomass, and renewables through local grids, central grid and hybrid systems to provide electricity access to over 900 million people within 50 years (Jiahua et al 2006).

The financing mechanisms for rural electrification in China changed with the different phases of its development. However, rural electrification projects are usually funded by the central government, local authorities and international funding agencies.

During the centrally planned economic development phase (1949-1977), most investments in rural electrification were carried out by local communities and local governments. This was because China was isolated from the rest of the world and faced enormous financial constraints (Pan et al. 2006). Although, the central government formulated a couple of policies during this era, up till the mid-1970s that incentivised investments in rural electrification, which, according to Pan et al. (2006), encouraged investors to invest in hydro resources.

[59] Bhattacharyya S.C. and Ohiare, S.M. (2012), The Chinese electricity access model for rural electrification: Approach, experience and lessons for others. Energy Policy: 40 (2012), 676-687

During the next phase of China's development (1977-1997), when the market became more open, the Chinese central government got more involved in funding rural electrification programmes. It did this via providing low interest loans, grants, in-kind contribution as well as making funds available through the Agricultural Bank of China. However, local governments reduced their investments in rural electrification in this era and relied on central government for funds, which posed a challenge for the rural electrification drive.

In the third phase (1998 till date), the Chinese government committed enormous resources to providing rural energy access and improving the network. Wang et al. (2006) reported that the government invested RMB 230 billion (£23 billion) in restructuring rural power grid between 1998 and 2003. Twenty Percent of this amount was provided by the central government, while the rest were provided by locally matched finance, and loans from development banks. The brightness programme and township electrification programs also got some billions of pounds equivalents of funding from the central and local governments (Wang et al. 2006). By and large, the role of both the central and local governments in providing and expanding access to rural electrification in China over the decades has been very crucial.

Nigeria can take a cue from China's experience in terms of political will and total commitment from government at various levels. Creating the enabling environment and policies for a multi-stakeholder approach and investment in rural electrification is also another lesson to be learnt by Nigeria from China's experience. Further, Nigeria should invest in detailed electricity planning for the country as well as decentralise/partner with relevant stakeholders in the business of rural electrification. Improvements in the economic lives of rural communities through agriculture and other productive activities are also crucial to rural electrification.

3.8.2 Brazil

Brazil is another good example of rural electrification success in the world having provided an overall electricity access rate of 97.8% by 2009, with 99.5% being urban and 88% being rural access (IEA, 2010). Brazil focused on its unique strength of using her majorly hydroelectricity potential (75%) and thermal sources (25%) to generate about 80GW of electricity. Electricity supply is mainly through Brazil's long high voltage grid-connected transmission lines of about 70,000km, and about 1000 mini-grid systems powered by diesel turbines (World Bank, 2007; Goldemberg et. al. 2004).

Rural electrification in Brazil is largely state-funded through Brazilian government owned Electrobras. The Light in the Countryside (LnC) and light for all (LpT) rural electrification programmes were implemented by Electrobras with the Ministry of Mines and Energy (MNE) as the supervisory ministry. Nigeria can learn from Brazil's experience of capitalising on one's unique strength in terms of energy resource potentials to provide rural electricity access. Building a long grid extension complemented with diesel-based mini-grids could also work for Nigeria given its huge crude oil reserves. Developing a robust electricity industry regulatory accounting system is also a lesson to be picked from here.

3.8.3 India

India is a rapidly developing Asian economic power-house with enormous need for electricity and energy to drive its increasing economic growth. According to IEA (2012), 293 million Indians have no access to electricity in India. Whereas, the country has an overall electrification rate of 75% while urban and rural level of electrification stood at 94% and 67% respectively. India has the world's largest rural population and the level of poverty in those areas is also high. Rural India is home to about 70% of the country's population and about 80% of the poor in the country (Modi, 2005).

According to Arya, Chanana and Kumar (2013), India's electricity is predominantly dependent on thermal power plants. Particularly, thermal power plants (coal, gas and oil based thermal plants) constitute 87.55% of the installed capacity while renewable sources which includes hydro, solar PVs, wind, tidal and nuclear plants accounts for the remaining 12.45% of the installed capacity.

India's electricity sector is predominantly financed and controlled by the central government (Modi, 2005), while Indian provinces are empowered to also exercise some level of control and regulation in their various localities.

The states which own and control State Electricity Boards (SEBs) are responsible for the generation, transmission and distribution of electricity in the states (Modi, 2005). Current power generation capacity as reported by Arya, Chanana and Kumar (2013) based on India's Ministry of Power data as at May 2013, is estimated to be 225.133 GW, out of which, the States contribute 86,343.35 MW (40.77%), the Central government 62,963.63MW (29.73%) and the private sector 62,459.24 MW (29.49%).

Grid extension has been the choice approach to providing electricity to communities in India. While generation is mostly centrally done transmission and distributed is to a large extent decentralised to states via the SEBs. According to Ahn and Graczyk (2012), who reported based on the International Energy Agency's (IEA) estimate, India may need investment in excess of $135 billion in order to achieve its universal electrification objective. Nigeria can learn from India's multi-model approach to rural electrification, as well as government commitment and strong regulations. Decentralization of transmission and distribution is also something worthy of note, while subsidies and variable tariff systems of India can be adopted for rural electrification in Nigeria.

Table 3.3 below summarises the experiences of a few other countries:

Table 3.3: Financing Rural Electrification in Various Countries

Country	Technological Option	Financing Sources and Mechanisms	Lessons
Philippines	Grid- Micro-hydro and geothermal Off-grid- SHS, Wind, Solar and mini/micro hydro	Government via NEA; Cooperatives, and private sources.	Effective local participation and off-grid solutions for isolated locations
Kenya	Grid-hydropower and geothermal, Off-grid- Solar PV	Government through REA, budgetary allocation, subsidies, grants and donors	Strong government commitment is lacking, despite huge renewable potentials and robust legal framework
Zambia	Grid Extensions Off-grid- SHS, mini-hydropower and diesel generators.	Government through electricity levies, REF, budgetary appropriation and loans.	Decentralization and reforms helped rural electrification, but energy resources potentials has not been fully tapped into, lack of private investments due to absence of supportive framework
South Africa	Grid-90% from coal Off-grid-SHS through ESCOs	Government through ESCOM, and private sources	Electricity was made a social right, gov't commitment and financial support/subsidies, emphasis on grid extension for rural electrification
Ghana	Grid extension Off-grid-solar PVs	Mainly Government funded, multilateral and bilateral loans	Planned electrification scheme with timelines and targets, government commitment.

3.9 Policy Implications

Given the critical role of energy services in the socio-economic and welfare development of rural areas, and the challenges posed by increasing energy prices, the World Energy Outlook of IEA (2011), reports that a number of actions have to be taken to achieve energy for all in 2030, or at least reduce the number of people currently without access significantly in the same period. The following are some of the proposed actions as reported by IEA (2011);

1) Make access to modern energy a matter of priority in the polity, such that government policies and funding would be consistently targeted towards this goal, and an efficient strategy for implementation adopted.
2) Additional investments for universal access have to be mobilized. Under the energy for all case of the IEA report (2011), $48 billion

worth of investment annually is required from 2010 to 2030 to achieve universal access to energy, while $14 billion is projected to be invested under the current trend. With the current trend, 1 billion people would still be without access to modern energy in 2030, thus, it is imperative to mobilise more investments to at least $34 billion per year to reduce significantly the challenge of lack of energy access in rural areas.

3) There is need for growth in private sector investment, therefore, barriers militating against the influx of private investments into the rural energy sector, must be addressed. Governments of developing countries have to provide the enabling environment in terms of governance and regulatory duties to attract more private investments into the sector. There is need for multilateral/bilateral agencies and the governments of various countries to invest in capacity building as well as develop practical business models that are sustainable and easily replicated.
4) Funds from multilateral and bilateral agencies should be focused on the most difficult energy access areas as a matter of priority, since such areas offer the least commercial returns. The use of microfinance institutions to provide end-user finance is imperative to solving the challenge of initial capital costs and building of capacity in the sector.
5) Comprehensive data collection and constant monitoring of activities in the sector will bring to bear outstanding challenges, which is a critical step towards eliminating them.

3.9 Summary

Findings from this review show that in order for the challenge of the lack of modern energy access to rural areas to be significantly alleviated or completely eradicated, there is the need to significantly increase financing for energy projects from all major sources of financing (private, multilateral banks, bilateral institutions and governments of developing countries). From the aforementioned sources, the private sector is expected to provide around

40% of the total investments required to provide energy for all between 2010 and 2030, as reported by IEA (2011).

However, there is currently an insignificant amount of investments and finance coming from the private sector, which is largely due to the unattractive nature of rural energy projects in terms of profitability and returns on investment. Thus, there is need for a concerted effort on the part of major stakeholders (governments, multilateral/bilateral institutions and researchers) to develop business models that are commercially-viable in providing large-scale modern energy services to the rural areas of developing countries.

The above gaps have to be filled by first embarking on country-specific studies and analysis of rural electrification access needs and investment requirements. Further, specific financing options that are realistic and specifically tailored for a particular country also needs to be identified and adopted. These gaps are filled for Nigeria's case in this thesis, as findings from the Network Planner analysis done in chapter four, as well as the scenario analysis and financing options suggested in chapter five are not only useful for Nigeria, but can be replicated in other developing Sub-Saharan countries.

CHAPTER FOUR
RURAL ELECTRIFICATION COSTS AND OPTIONS IN NIGERIA: AN APPLICATION OF THE *NETWORK PLANNER MODEL*

4.1 Introduction

This study adopts the '***Network Planner'*** **(NP)** Model developed by the Earth Institute of Columbia University, New York. The 'NP model' has been useful in carrying out electricity expansion and planning studies hitherto in four Sub-Saharan Africa countries – Kenya (Parshall et al. 2009) Ghana Kemausuor et al. 2012), Senegal (Sanoh et al, 2012) and Liberia (Modi et al. 2013). Other models that were initially considered for this research are HOMER Micro-optimisation software, and the RETScreen Model. HOMER and RETSCREEN work at project levels whereas NP works at regional or macro levels. The first two are for project viability analysis whereas NP is for network expansion planning.

The HOMER software is a computer optimisation software used in designing micro-power systems for effective evaluation of different renewable energy and hybrid systems. HOMER does more of technical analysis and is based on life cycle costs of the system's life span. Although, it allows for the modelling of grid-connected and off-grid systems, it focuses on power generation and also allows for simulation and sensitivity analysis. RETScreen on the other hand allows you decide whether or not a proposed renewable energy, energy efficiency, or cogeneration projects is financially viable or not. It also allows for sensitivity and risk analysis, cost analysis and emission analysis, thus, it is biased towards renewable energy systems.

However, the Network Planner model was applied for this research because of its uniqueness as an electricity planning model that helps with decision making as regards which areas grid expansion makes sense, as well as which areas decentralized options are cost-optimized. It was the only feasible model that could be used for this research to answer the first two research questions. It allows for three technologies: Grid electrification (internal grid and external connection to existing grid system); Mini-grid based on diesel generator; and Off-Grid based on solar PV panel with small diesel generator supporting it for production purposes. The Model also allows for the incorporation of a Geographical Information System (GIS) tool that performs a spatial analysis and processing based on simple population and geospatial data, which algorithmically generates a detailed, cost-optimized electricity plan that produces a map of projected grid extension, areas to be served with off-grid options, and estimated costs for providing these options over a time horizon.

The model can perform at National, State, Regional or Community levels based on data availability and output from the model can be visualized on a map using Arcmap or any other mapping tool to show projected electrification targets based on existing grid network maps. It also allows for sensitivity and scenario analysis that helps planners understand what happens to electrification costs if certain variables change. Thus, the choice of the NP model for this research stems from the fact that it is more useful in answering the first two research questions of this thesis, and has advantages over the previously considered models especially in the areas of electricity network planning and GIS modelling.

The model was used in this research to estimate the cost of increasing access to electricity to households and populations currently without electricity in Nigeria which in turn provides a suitable basis for discussing financing options in chapter 5. The result of the data analysis of the 'NP Model' answers the first and second questions of this research.

Given the geopolitical characteristics of the federating units in Nigeria, the study does a national analysis of the whole country, covering the 36 states, using data from all the 774 Local government areas (LGAs) of Nigeria. The aim is to increase the electricity coverage in each of these states from the present level to 100% percentage penetration rate in 17 years i.e. from 2013 to 2030. By extension, using the population of these states (adjusted to 2013 projection using a growth rate of 2.65%), this implies providing electricity to an estimated 28.5million households or 125million people by 2030.

Table 4.1 below shows the percentage of people without grid-electricity in each state in Nigeria by geo-political zones; North-West (NW), North-Central (NC), North-East (NE), South-West (SW), South-East (SE), and South-South (SS).

Table 4.1: Percentage of persons without access to grid-electricity in each state in Nigeria by Geo-political Zones

NW	%	NC	%	NE	%	SW	%	SE	%	SS	%
Jigawa	56.5	Benue	72.0	Adamawa	71.4	Ekiti	15.2	Abia	33.3	Akwa Ibom	38.3
Kaduna	42.4	Kogi	48.1	Bauchi	58.5	Lagos	0.3	Anambra	38.3	Bayelsa	36.9
Kano	56.2	Kwara	38.5	Borno	77.3	Ogun	20.4	Ebonyi	68.1	Cross River	46.3
Katsina	59.7	Nassarawa	70.6	Gombe	55.4	Ondo	41.9	Enugu	48.5	Delta	46.3
Kebbi	54.4	Niger	56.6	Taraba	88.8	Osun	33.9	Imo	12.6	Edo	15.2
Sokoto	69.5	Plataeu	71.3	Yobe	78.0	Oyo	38.8			Rivers	21.7
Zamfara	77.1										
Average	59.4	**Average**	59.5	**Average**	71.6	**Average**	25.1	**Average**	40.2	**Average**	34.1

Source: National Bureau of Statistics (NBS) 2009

4.2 Model Description and Application

The network planner (NP) model is a decision support tool that determines the least-cost technology – either grid electrification or an off-grid alternative – to connect each population centre, which is referred to as a demand node in this research. The NP model uses data on electricity costs and demand, population, and other socio-economic data to estimate detailed cost projections for three electrification technology options: (a) Off-Grid (solar PV panel supported by small diesel generator for production use), (b) Mini-Grid (solely on diesel generator) and (c) Grid electrification (internal grid plus external connection to the existing grid network). The NP model then recommends the most viable and optimal cost-effective option for electrifying an area within a fixed time horizon. This enables planners to have an insight into areas that grid expansion is more viable option and where other decentralized options offer the cost-optimized alternatives for electrification purposes.

The model also combines Geographic Information System (GIS) tool to execute spatial processing and investigation, using relevant population and geospatial data, and algorithmically creates a detailed, cost-optimized electricity proposal, including a map of the estimated grid extension, areas to use off-grid technologies, and other associated costs. Based on available data, the model can generate results at any geographical scale - national, state or local levels.

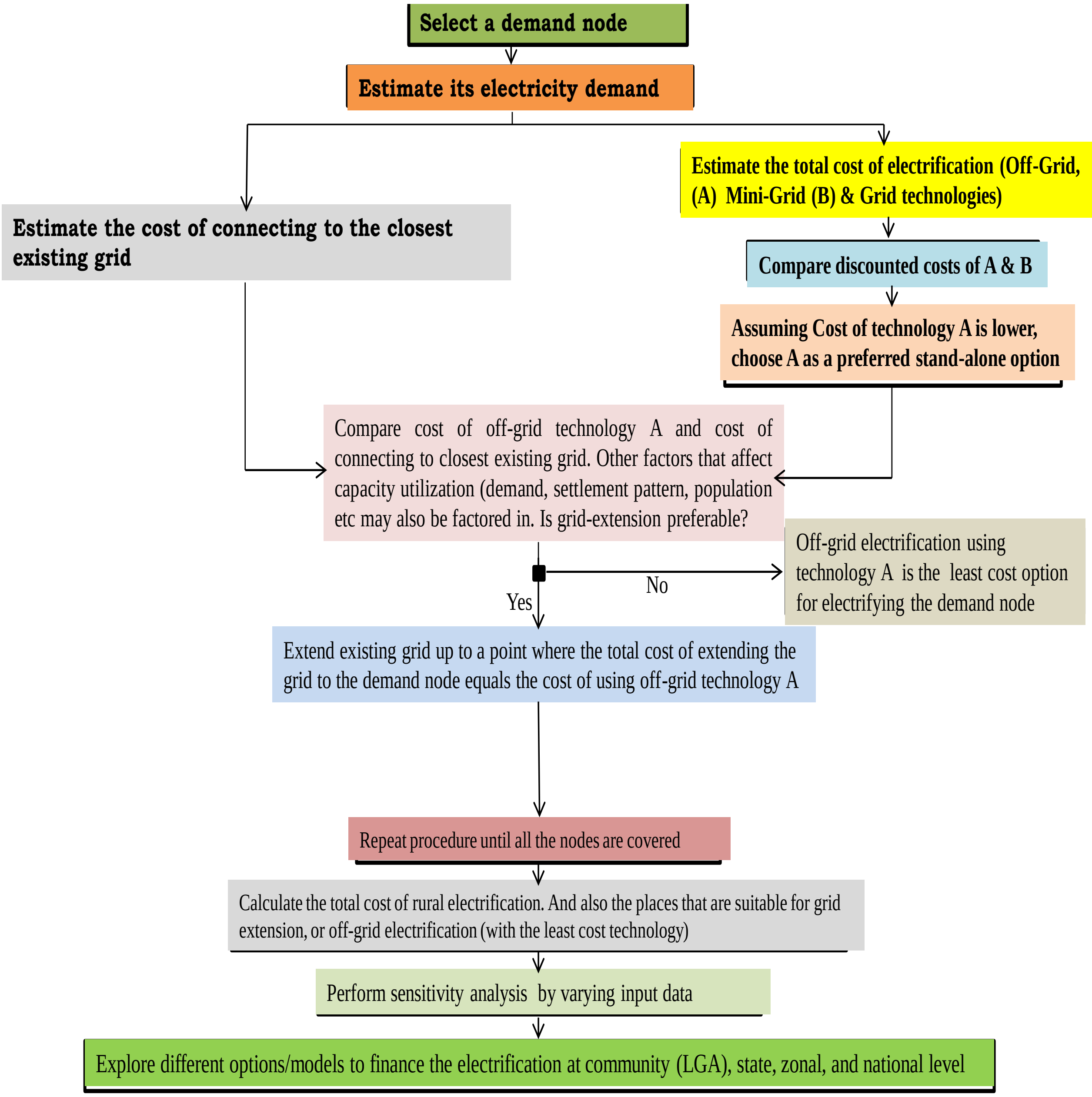
In order to obtain a reasonable estimate of the total cost given the vastness of the Nigerian landmass, diversity of physical terrain, diversity of climatic conditions, and unavailability of community-based data, we simplify the number of demand nodes from thousands of rural communities/villages to all the 774 Local Government Areas (LGAs) in the 36 states of Nigeria where access to electricity is lacking with an inherent assumption that the heterogeneity of communities in a particular Local Government Area will be minimal. This allows for the use of available demographic and socio-economic data that are available at the LGA levels.

Results derived from the 'NP model' can be implanted on a map to show various areas with their proposed and existing grid network linking the LGAs, as well as their proposed targeted electrification. The NP model also allows for various scenario and sensitivity analysis to be performed. By changing input variables such as prices and demand, and running different scenarios, the 'NP model' enables planners to understand the effect this would have on electrification costs.

The main aim of using this model is to estimate the cost of expanding electricity access to the millions of households currently without access in Nigeria, and select the least-cost technology to achieve this in different LGAs. As noted by (Parshall, Pillai, Mohan, Sanoh, & Modi, 2009), "The model is not meant to replace detailed engineering analyses of grid rollout, including load-flow analysis, which would be needed as part of the implementation process, so it cannot be used as a stand-alone implementation tool".

The schematic workflow/analytical framework of this research are presented in the figure below.

Figure 4.1: Schematic Work-flow and Analytical Framework



4.3 Data Requirement and Collection

The gathering of data constituted a fundamental challenge to this research. The researcher anticipated this in the preliminary phases of this research, especially considering the difficulty in accessing data from a developing country such as Nigeria, which in most cases are simply not available, and in other cases are hoarded by various vested interests in the industry. As a guide for this research, a framework for the data collection was adopted from previous studies. A formal request for data letter was sent out to all the relevant stakeholders listed below;

- National Bureau of Statistics (NBS)
- Nigerian Electricity Regulatory Commission (NERC)
- Power Holding Company of Nigeria (PHCN)
- Transmission Company of Nigeria (TCN)
- Generation Company of Nigeria (Gencos)
- Distribution Company of Nigeria (Discos)
- Energy Commission of Nigeria (ECN)
- National Population Commission (NPC)
- Rural Electrification Agency (REA)
- States and Local Governments contacts
- Mikano Generators International
- Arthur Energy Technology Ltd.

The response was positive, and available data were sent to the researcher after so much pressure and emails, as well as a consistent follow-up from contacts within Nigeria. The initial data collection framework was presented in Table 1.5 in chapter 1. This was used as a guide for this research.
However, during the modelling exercise when the researcher travelled to the Energy Centre at the Kwame Nkrumah University of Science and Technology in Ghana for one month training on the use of the 'NP model', it was realised that there was the need for more data to be used for the analysis.

All efforts to source more data from the relevant agencies yielded no result, as they were unavailable. The researcher relied on reasonable assumptions in consultation with practitioners and in some cases resorted to purchasing data from consultants and private data banks to make up for the rest of the data requirements for this research. Further, by virtue of being an intern at the Nigerian Bulk Electricity Trading PLC (NBET) since September 2013, the researcher had unfettered access to stakeholders and agencies within the Nigerian Electricity Supply Industry (NESI), which made stakeholders' interviews and discussions in chapter five, as well as the membership of the committee reviewing the draft Rural Electrification Strategy and Implementation Plan (RESIP) possible.

The new data framework developed and used for the base scenario analysis of this research is shown in the tables below.

Table 4.2: Nigerian Socio-Economic Data Used in Modelling[60]

SOCIO-ECONOMIC DATA	Unit	Parameter	Sources
FINANCING PARAMETERS			
Time Horizon	(years)	17	Author
Interest Rate per year	Percentage	20.58	CBN
Economic Growth Rate per year	Percentage	6.58	CBN
Elasticity of Electricity Demand	Dimensionless	0.018	ECN
DEMOGRAPHICS PARAMETERS			
Mean Household Size (Rural)	(persons)	4.6	NPC
Mean Household Size (Urban)	(persons)	4.1	NPC
Urban Population Threshold	(persons)	20,000	NPC
Mean Inter-household Distance	(meters)	25	Consultation with experts
Population Growth Rate per year (Rural)	Percentage	1.31	World Bank data
Population Growth Rate per year (Urban)	Percentage	4.0	World Bank data

[60] All costs, financial, economic and other data were collected and calculated in local currency. However, they were converted to US$ for ease of presentation and for better understanding.

Table 4.3: Nigerian Demand Data Used in Modelling

DEMAND PARAMETERS	Units	Parameter	Sources
HOUSEHOLD DEMAND			
Base Household Unit Demand per Household	(kWh/yr)	330	Based on previous studies, consultation with experts and computation of available data
PRODUCTIVE DEMAND			
Base Productive Unit Demand (per Household)	(kWh/yr)	19.5	
SOCIAL INFRASTRUCTURE DEMAND			
Base Health Unit Demand (per Health Facility)	(kWh/yr)	1000	
Base Education Unit Demand (per Education Facility)	(kWh/yr)	1200	
Base Commercial Unit Demand (per Commercial Facility)	(kWh/yr)	550	
Base Public Lighting Unit Demand	(kWh/yr)	292	
PEAK DEMAND			
Fraction of total demand during peak hours (rural)	Dimensionless	0.4	
Fraction of total demand during peak hours (urban)	Dimensionless	0.4	
Annual peak usage hours	(hrs/yr)	1460	

Table 4.4: Nigerian Off-Grid Cost Data Used in Modelling

COST DATA	Details	Units	Parameter	Sources
SYSTEMS COST PARAMETERS				
OFF-GRID: PHOTOVOLTAIC SYSTEMS + STAND-ALONE DIESEL GENERATORS				
Photovoltaic Systems				
Available Panel System Sizes	system sizes	(KWp)	4wp	Based on consultation with experts and computation of available data
Panel cost per system kilowatt	panel cost per system kilowatt	(US$/kW)	2000	
Balance of System cost factor (as fraction of Panel cost)	balance cost as fraction of panel cost	Dimensionless	0.5	
Battery energy per system kilowatt	battery kilowatt-hours per system kilowatt	(kWh/kW)	4.5	
Battery cost per kilowatt-hour	battery cost per kilowatt-hour	(US$/kWh)	125	
Photovoltaic Systems Replacement				
Panel lifetime	panel lifetime in years	(years)	20	
Balance of System lifetime	balance lifetime in years	(years)	10	
Battery lifetime	battery lifetime in years	(years)	5	
Operation and Maintenance (O&M)				
O&M Photovoltaic Systems cost factor (as fraction of total Panel System cost)	operations and maintenance cost as fraction of system cost	Dimensionless	0.05	

Table 4.5: Nigerian Mini-Grid Data Used in Modelling

COST DATA	Details	Units	Parameter	Sources
MINI-GRID: DIESEL GENERATORS				
Diesel Generators				
Available Diesel Generator System Sizes Standard units for diesel generator system sizes are represented in kVA; kVA=kW*Power Factor	system sizes	(kW)	1000;750; 500; 400;200; 150; 100; 70;32; 19; 12; 6.	Based on consultation with experts and computation of available data
Diesel Generator cost per kilowatt	engine cost per kilowatt	(US$/kW)	300	
Diesel Generator Installation cost factor (as fraction of Diesel Generator cost)	engine installation cost as fraction of engine cost	Percentage	25	
Diesel Generator Replacement				
Diesel Generator lifetime	engine lifetime in years	(years)	5	
Fuel				
Fuel cost per litre	fuel cost per litre	(US$/L)	0.96	
Fuel litres consumed per kilowatt-hour	fuel litres consumed per kilowatt-hour	(L/kWh)	0.22	
Operation and Maintenance (O&M)				
Total hours diesel generator is in operation in a year	fuel hours per year	(h/yr)	1460	
Diesel Generator O&M cost factor (as fraction of Diesel Generator cost)	operations and maintenance cost as fraction of engine cost	Percentage	5	

Table 4.6: Nigerian Mini-Grid & Grid LV Data Used in Modelling

MINI-GRID & GRID: Low Voltage Distribution Network	Units	Parameter	Sources
Low Voltage Lines			
Low Voltage Line cost per meter	(US$/m)	US$ 12 and US$ 17	NED, EC
Low Voltage Lines Replacement			
Low Voltage Line Lifetime	(years)	20	NED
GRID: Transformers + Household & Social Infrastructure Connections + Extension			
Electricity cost per kilowatt-hour	(US$/kWh)	0.14	NERC
Transmission and distribution loss factor (as fraction of grid system demand)	Dimensionless	0.198	NERC
GRID: Transformers			
Transformer in Low Voltage Network			
Available transformer system sizes (kVA)	kW	5 ,15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000	Mikano Generators
Transformer cost per kilowatt	(US$/kW)	152	Based on computation of available data
Transformer Replacement			
Transformer lifetime	(years)	20	
Operation and Maintenance (O&M)			
Transformer O&M cost factor (as fraction of Transformer cost)	Dimensionless	0.03	

Table 4.7: Nigerian Grid Data Used in Modelling

GRID: Household & Social Infrastructure Connections	Details	Units	Parameter	Sources
Connections to Low Voltage Network				
Equipment cost per connection	equipment cost per household (Up to 40 meters distance)	(US$/HH)	250	Calculation based on previous study
Installation cost per connection	installation cost per household	(US$/HH)	70	Transmission Company of Nigeria (TCN)
Equipment O&M cost factor (as fraction of Equipment cost)	equipment operations and maintenance cost as fraction of equipment cost	Dimensionless	0.01	
GRID: Medium Voltage Extension				
Medium Voltage Lines				
Medium Voltage Line cost per meter	material and labour cost in dollars per meter of grid extension	(US$/m)	193	TCN
Medium Voltage Lines Replacement				
Medium Voltage Line Lifetime	lifetime in years	(years)	30	TCN

4.4 Estimation of Projected Population and Demand

The electricity demand in each LGA is estimated using data on a number of households and household energy use in each LGA. The basic household energy demand in rural communities are for cooking, lighting, heating, water pumping, agro-related purposes and to power gadgets used in micro-enterprises (Haanyika, 2006).

In every demand node, the increase in demand for electricity is subject to economic and/or population growth(s). Thus demand nodes with high population and high economic growth rates have higher electricity demands, and vice versa. In the same way, households in cities/towns and large settlements tend to have higher electricity demand than those in the rural areas.

Thus, taking all these factors into consideration, data for the base year (2013) urban and rural population growth rates from the NPC, population of people without access to electricity, and geospatial data (latitude and longitude coordinates) of all the 774 LGAs of Nigeria are processed and uploaded into the model. In projecting the population to the final year of planning horizon (2030), the model applies various population growth rates to urban and rural areas based on the user-defined urban threshold (i.e. the value of a size of population below which a demand node is considered rural and above which it is urban).

The model then applies the population growth rate every successive year till the last year of the planning horizon, including provisions allowing for a rural community to start up with the rural growth rate and end up with the urban growth rate as its population out-grows the urban-rural threshold.

The blend of Nigeria's economic growth rate, mean household size, peak demand data, population growth rate (rural and urban), and the base year electricity unit demands of the communities are used to project the total electricity demands needed at the end of the specified time horizon.

4.5 Estimation of Cost for Each Technology

Detailed cost components of the chosen electrification technologies such as the cost of low voltage (LV) lines, medium voltage (MV)[61] lines, transformers, diesel fuel per litre, diesel generators, solar panels and solar batteries, plus recurring costs, comprising operation and maintenance are required by the model. The model also needs interest rate per year to be used to determine the discounted costs for each technology option. This was combined with other cost components to estimate the projected cost of electrification for each technology choice based on the projected electricity demands at the completion of the planning time limit.

[61] Nigeria uses 16Kv and 33kV lines for power distribution, as well as 132Kv and 330kV High Voltage (HV) lines for power transmission. The NP model uses Low Voltage (LV) and Medium Voltage as the default lines for analysis. However, the MV lines used in this research include the cost of connecting 16kV, 33kV, 132kV and 330kV in line with what is obtainable in Nigeria. Therefore, the HV lines are incorporated in the NP model as MV lines for ease of representation and conformity with the model.

4.6 Selection of Least-Cost Technology

Given the projected electricity demand for each demand node over the specified time horizon (2013 to 2030), the model first calculates the total costs of electrification comprising all preliminary and recurrent expenditures for the three different electrification technology alternatives.

The select-three technologies are: (a) Off-Grid-which is defined as a hybrid of solar photovoltaic (PV) and diesel generator for household and productive use respectively, (b) Mini-Grid- defined as diesel generator plant with low voltage (LV) supply for all types of demand (productive, household, social infrastructure etc.) and (c) Grid Electrification- this is sub-divided into two grid connections and costs groupings (internal and external). While the "internal" grid connection involves cost of transformers, secondary MV-lines[62], LV lines and internal house wiring for connecting households, institutions and other structures within the demand node, the "external" grid connection entails extending the MV lines from a transformer in the demand node to the closest MV grid network.

Subsequently, the discounted costs of the two ''stand alone" technology options i.e. the Off-Grid and Mini-Grid are compared, and the one with the least cost is selected. The selected stand-alone option is further compared with the discounted cost of only the internal element of grid connection costs of the demand node. If the least cost stand-alone option has a lower cost than the internal component of the grid cost, then the grid connection is regarded as the unviable option for the demand node, and the model selects the least-cost stand-alone technology as the optimal electrification option.

However, if the internal grid component is lower in cost than the least-cost standalone alternative, then the difference between these two costs forms the budget available for the external part of the grid connection costs for

[62] Ibid note 62

such demand node, which is called the MV line to connect to the nearest grid location.

By dividing this value by the cost of MV-line per meter, the model obtains a key decision metric, 'MVmax' for each demand node. The MVmax, expressed in meters, denotes the maximum length of MV-line which can be connected for each demand node before the cost of grid extension exceeds the cost of the least-cost stand-alone option.

The metric is specific to each demand node and provides a basic estimate of how far the existing MV- line network can be cost-effectively extended to reach this demand node. The household cost of connection is not considered as it is an internal cost

Lastly, the model uses geospatial algorithm to compare these MVmax values with the actual distances between the location of unconnected communities (identified by latitude and longitude coordinates), and identifies those sites with MVmax values that justify grid connection. Those communities that are selected, indicating that grid extension is the most cost-effective technology to electrify a community, are recommended for grid connection by the model; in other words, they are 'grid-compatible'. Those demand nodes beyond the MVmax values are on the other hand, are recommended for electrification using the least-cost stand-alone alternative.

It should be noted here that although Nigeria has various energy resources (renewable and conventional), and could have easily tapped into its extensive natural resources such as biomass, hydro (mini & micro), gas, wind, biomass etc. for this research. The choice of Solar/diesel hybrid for the Off-grid option and Diesel generator plant for the Mini-Grid stems from the fact that their costs and resources are fairly well available and understood, suffice to say that the technology can be easily applied in every part of Nigeria.

Specifically, biomass gasifiers which was a technology choice that was closely considered given the huge agricultural activities going on in rural Nigeria, had to be dropped due to its limited success from the experiences of other countries in its usage especially in India (Ghosh et al. 2006) and Sri Lanka (Abeygunawardana 2011). Technology management and the poor quality of the product are reasons attributed to its failure[63].

4.7 Estimation of Investment Cost/Requirement Using the NP Model

It is important to point out specifically which part of this model deals with the central question of estimating the investment costs and financing requirement of rural electrification in Nigeria.

In the course of estimating the different costs of the select-three technology options (Off-Grid, Mini-Grid and Grid), as well as comparing them to see the least cost/most viable option, the *Network Planner Model* performs a financial analysis. It does this by estimating the Net Present Value (NPV) of the 17-year discounted capital and maintenance costs for each technology option based on the unit costs of appropriately sized equipment.

The cost of the technology for all cases includes installation of equipment and transportation. For grid extension, capital costs cover LV line to connect households and institutions, MV line and transformers, poles, and other household equipment such as lamps and wire. However, costs do not include generation, institutional capacity building, and reinforcement of the existing distribution network.

The diesel mini- grid cost structure is similar to national grid extension but includes the cost of an appropriately sized diesel generator for the demand node. Solar PV plus diesel capital costs include solar panels and batteries for domestic demand and a diesel generator for productive demand. Note

[63] Palit, D. and Chaurey, A., (2013) Off-Grid Rural Electrification Experiences from South Asia, in Bhattacharyya, S.C. (ed.), Rural Electrification through Decentralised Off-grid Systems in Developing Countries, Green Energy and Technology, London: Springer-Verlag. Pp. 75-104

that since the decentralized options are stand-alone systems of distribution, costs associated with generating electricity using solar PV and/or diesel generator are included. In the case of grid extension, generation costs are included indirectly through the cost of MV electricity purchases.
Therefore, the above financial analysis performed by the model gives us a guide as to the investment costs/financing requirement of rural electrification in Nigeria.

4.8 Results and Analysis

Base Scenario

The following assumptions were used for the base scenario: 100% electrification rate by 2030, with 2013 being the base year; current pump price of diesel fuel per litre of US$0.96, 1460 hours operation of diesel mini-grid per year; average household demand of 330kWh per year; a mean inter-household distance of 25 metres and a rural-urban population threshold of 20,000. All input model data were obtained in 2013 except the population data that was projected from 2006 to 2013 using a 2.8% growth rate estimate of the National Bureau of Statistics (NBS). Table 4.8 below shows the base scenario results of the national costs of electrification in Nigeria based on the NP modelling analysis.

Table 4.8: Cost Estimates for Rural Electrification in Nigeria

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost Million (US$)	Initial Cost Per Household (US$)	System Total Recurring Cost per Year Million (US$)	Recurring Cost per Household (US$)
Grid LV + Transformer	27,833,318	98%	23,041	828	8,742	314
Grid MV			1,991	72	101	4
Grid Total			25,032	899	8,843	318
Mini-grid	645,644	2%	500	775	162	252
Off-grid	-					
Grand Total	28,478,962	100%	25,533	897	9,006	316

At the national level, an overall total cost of US$34.539 billion is estimated for the initial and yearly recurring costs for the 17 year planning period. A total number of 28.5million households are to be electrified by 2030, which translates to an estimated 125million people. Currently, an estimated 73million Nigerians lack access to electricity going by the NBS figures of 2013.

The results further show that 98%[64] of the households currently without access are to be electrified via Grid expansion, while the remaining 2% will be electrified through mini-grid technology. The average connection cost per household for grid technology is US$899, while that of the mini-grid is US$775. Recurring cost per household per year for grid technology households is US$318, while that of mini-grid is US$316[65].

[64] This figure is this high because of the large rural population of each of the 774 Local Government Areas used for this analysis. This LGA level is the lowest unit of administration in Nigeria and data below this level is unavailable. However, it is one of the recommendations of this research that the possibility of creating an energy access database of lower levels (small rural villages and communities) be explored as soon as possible.
[65] The NP model selects the least cost supply option based on data for specific locations, population size, economy, costs of technologies etc. Thus, if mini-grid is selected for a particular demand node, which means it is the cheapest to use there, same for grid and off-grid choices. Further, the results show that 98% of households

The system total levelized cost for the grid and mini-grid technologies are estimated at US$0.30 and US$0.47[66] per kWh respectively, over the planning period. Total length of MV and LV lines proposed under the base scenario are 12,193,060 metres (12,193 kilometres) and 711,954,700 metres (711,954 kilometres) respectively. Nigeria currently has a total transmission line of 12,337 kilometres, that is, 5,650 kilometres of 330kV transmission lines, and 6,687 kilometres of 132kV transmission lines. The implication of results from the analysis is that an additional 12,193Kilometres of MV lines is required for 100% expansion of electricity to rural Nigeria. Unfortunately, data for the LV distribution lines in Nigeria is not available to researcher for comparison with the result derived from this research.

Overall, an average of $2billion dollars annually is required for the next 17 years (2013 to 2030), in order to achieve 100% penetration rate of rural electrification in Nigeria. This will provide new access to electricity for an average of 1.68million households yearly between the planning years (2013 to 2030).

In order to get a more disaggregated result, the same process applied to get the national level result was also applied to each of the 36 states of Nigeria and the capital city of Abuja. This entailed collating data for all the Local Government Areas of all the states and running the model for each of the states in Nigeria. Table 4.9 below shows the base scenario results of a more disaggregated electrification cost estimates for various states in Nigeria. However, a detailed breakdown of cost estimates for each of the states is presented in appendix 2 of this thesis.

in different locations in Nigeria are grid-compatible, while the remaining 2% are mini-grid compatible, and goes to show the total, average and recurring costs at such levels. Whichever location is selected as mini-grid for instance, then the grid and off-grid costs are definitely higher in such locations, and vice versa.

[66] The levelized costs for the grid and mini-grid are large because of the 17 year planning period used in the modeling. An increase in the planning period from 17 to 30 years to allows more time for cost recovery, thus, reduces the levelized cost for grid supply to $0.20/kWh, and mini-grid to $0.33/kWh. A screenshot of this is provided in appendix 5. The $0.14 used as the electricity cost per kWh was used to capture costs of generation, transmission, distribution of power to various parts of Nigeria (see screenshot in appendix 6 for data input into the model).

Table 4.9: Cost Estimates for Rural Electrification of Various States in Nigeria

State	Total Number of Households Electrified	Percentage of Households Electrified		Cost of Grid (US$)			Cost of Mini-Grid (US$)		
		Grid	Mini-Grid	Total (Million $)	Per HH	Leve-lized	Total (Million $)	Per HH	Leve-lized
Abia	411,623	98%	2%	439	1,084	0.38	6	995	0.50
Adamawa	1,048,161	98%	2%	1,349	1,288	0.29	18	1,047	0.46
Akwa-Ibom	972,903	100%	-	1,047	1,077	0.35	-	-	-
Anambra	295,991	90%	10%	2,743	1,030	0.41	29	1,006	0.49
Bauchi	951,368	98%	2%	1,241	1,338	0.27	26	1,107	0.44
Bayelsa	315,937	100%	-	361	1,144	0.35	-	-	-
Benue	1,198,680	100%	-	1,511	1,261	0.28	-	-	-
Borno	1,589,400	100%	-	2,287	1,439	0.26	-	-	-
Cross river	650,128	97%	3%	742	1,184	0.35	23	1,023	0.48
Delta	1,145,787	100%	-	1,245	1,087	0.34	-	-	-
Ebonyi	637,375	100%	-	757	1,189	0.30	-	-	-
Edo	106,335	69%	31%	72	991	0.42	32	991	0.50
Ekiti	325,939	95%	5%	334	1,082	0.42	16	1,000	0.49
Enugu	770,522	100%	-	867	1,126	0.32	-	-	-
FCT-Abuja	245,440	89%	11%	327	1,501	0.24	27	1,028	0.47
Gombe	601,375	100%	-	768	1,278	0.27	-	-	-
Imo	195,075	65%	35%	132	1,035	0.43	67	997	0.49
Jigawa	1,060,396	100%	-	1,336	1,261	0.29	-	-	-
Kaduna	1,248,819	100%	-	1,598	1,280	0.27	-	-	-
Kano	1,729,744	100%	-	2,147	1,241	0.28	-	-	-
Katsina	1,405,492	100%	-	2,009	1,430	0.31	-	-	-
Kebbi	750,452	97%	3%	874	1,200	0.32	22	1,068	0.45
Kogi	756,733	92%	8%	806	1,158	0.36	62	1,037	0.47
Kwara	323,549	76%	24%	259	1,056	0.38	80	1,031	0.47
Lagos	343,028	96%	4%	327	997	0.38	14	994	0.50
Nasarawa	457,742	96%	4%	532	1,211	0.33	18	1,038	0.47
Niger	1,098,726	100%	-	1,303	1,186	0.30	-	-	-
Ogun	515,463	94%	6%	505	1,041	0.37	30	1,000	0.49
Ondo	828,557	100%	-	902	1,089	0.35	-	-	-
Osun	457,604	96%	4%	449	1,019	0.41	16	995	0.50
Oyo	865,891	79%	21%	730	1,063	0.37	182	1,020	0.48
Plateau	829,789	100%	-	1,104	1,331	0.28	-	-	-
Rivers	797,321	100%	-	890	1,116	0.33	-	-	-
Sokoto	1,026,713	98%	2%	1,270	1,260	0.30	20	1,055	0.46
Taraba	910,651	96%	4%	1,184	1,353	0.29	39	1,137	0.42
Yobe	685,347	97%	3%	818	1,226	0.29	18	1,055	0.46
Zamfara	907,400	100%	-	1,235	1,361	0.27	-	-	-
High	1,729,744	100%	35%	2,287	1,501	0.43	182	1,137	0.50
Average	769,229	95%	2%	920	1,190	0.33	35	1,031	0.47
Low	106,335	65%	9%	72	991	0.24	6	991	0.42

From table 4.9 above, we observe that Kano state in the North-western part of Nigeria and the most populous state in Nigeria according to the 2006 census have the highest number of households without electricity at 1.8 million people approximately. An average of 769 thousand households in each state of the federation lack access to electricity, and the state with the least number of unelectrified households is Edo state at 106 thousand households approximately.

As expected, the grid technology is the preferred and least cost technology for rural electrification in most states, with most states going 100% grid, and averagely 95%, while the state with the least grid penetration is Imo state in South-Eastern Nigeria, with a recommended grid penetration rate of 65%. The Mini-grid technology has an average of 2% in terms of households electrified, and Imo state again takes the lead as the state with the highest mini-grid recommended technology at 35%.

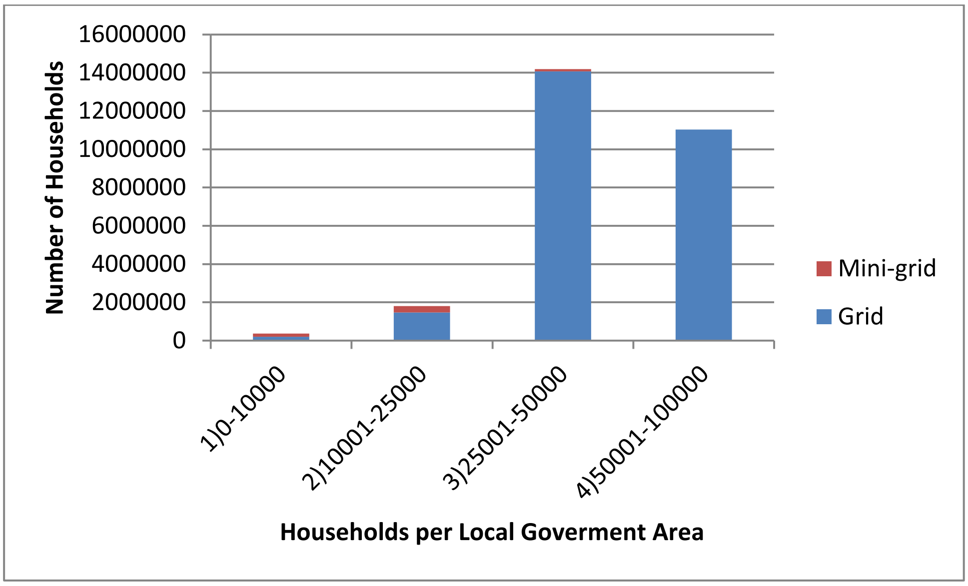
We also observe that while Kano state has the highest number of unelectrified households, it is not necessarily the most costly state to electrify. Borno state is the most costly grid-based state to electrify in Nigeria with an approximate cost of US$2.9 billion, while the least expensive grid-based state to electrify is Edo state at US$73 million. An average cost of US$1 billion dollars would be required to electrify each state in Nigeria. Reasons for this disparity in costs for grid based electrification for different regions can be attributed to distance of locations from existing grid infrastructure, topography and population size of different regions.

For Mini-grid recommended households, Oyo State in South-West Nigeria will require an estimated US$183 million being the highest for Mini-grid component of its electrification, while an average of US$35 million of mini-grid technology investment is required for electrification of various states in Nigeria, and Abia State in South-East Nigeria requires about US$6 million for its mini-grid component of rural electrification.

Taraba state which is currently the least electrified state in Nigeria requires 96% grid extension and 4% mini-grid technology for rural electrification. This translates into $1.18 billion for grid expansion and $39.7 million cost of mini-grid investment for rural electrification over the planning period.

The levelized costs of each system technologies as well as costs per households are also shown in table 4.6 above. We observe that the average levelized cost of grid-based electrification (US$0.33) is lower than the mini-grid electrification of (US$0.47). However, the cost per household of the mini-grid electrification option (US$1031) is lower than that of the grid (US$1190) on the average[67].

Figure 4.2: Base Scenario Household Count by Bin Type[68]



With the aid of the pivot table tool of Microsoft Excel 2010, the demand assumptions were categorized into four household level population sizes. The household bins are defined as: 1)1-10000, 2)10001-25000, 3)25001-50000, 4)50001-100000, and 5)>100000. Figure 4.2 above shows the base scenario household count by bin categorization. We observe from the graph that Mini-Grid technology is only viable in areas with populations between 1 and 25,000 households. However, household bins of 25,001 and above are 100% grid recommended. This goes to show that grid technology makes more economic sense in areas of higher/dense population that sparsely populated areas.

Table 4.10 below shows the estimated grid extension for the proposed MV and LV lines needed to connect households in various States in Nigeria. For

[67] *Ibid* note 62
[68] The large bin sizes as used here represent the large rural population data available at the disaggregated level of Local Government Areas in Nigeria.

grid compatible LGAs, the total MV and LV lines required to connect about 27.8 million proposed grid compatible households currently without access to electricity in Nigeria are 12,341,906m and 711,954,700m respectively. Furthermore, Nigeria requires an average of 0.43m of MV grid length and 25.01m of LV grid length to connect various households in each LGA that are grid compatible

A break-down of the total length of MV and LV gridlines proposed per state from table 4.10 below shows that Borno State has the highest proposed MV gridline of 883,698m, while Kano state has the highest proposed LV gridline of 43,242,500m, and Nasarawa state has the highest proposed MV gridline per household of 0.77m. The three states are in the Northern region of Nigeria. On the other hand, Edo state has the least proposed MV and LV gridlines of 26, 271m and 2,657,925m respectively, while Lagos state has the least proposed MV line per household of 0.11m. Both states have the highest existing grid coverage in Nigeria which makes them require relatively short lengths of MV lines needed to connect households compared to the North, and Lagos especially is highly populated with a high population density. Both states are in the southern part of Nigeria.

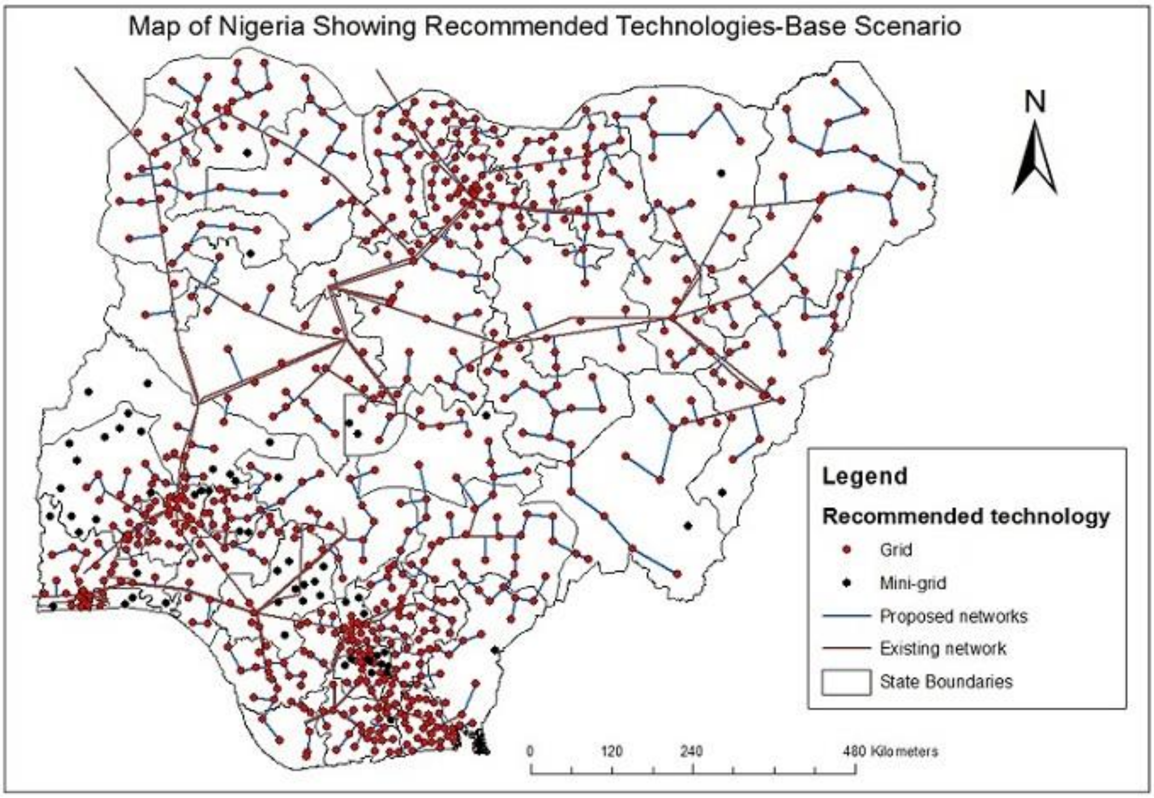
Table 4.10: Proposed Length of MV and LV Lines for Each state in Nigeria

State	Total Number of Households Electrified	Length of Proposed MV Lines		Length of Proposed LV Lines	
		Total (thousand metres)	Per Household (Metres)	Total (Million Metres)	Per Household (Metres)
Abia	411,623	181	0.44	10	25.00
Adamawa	1,048,161	518	0.49	26	25.42
Akwa-Ibom	972,903	278	0.29	24	25.00
Anambra	295,991	105	0.36	7	25.00
Bauchi	951,368	508	0.53	23	25.00
Bayelsa	315,937	161	0.51	7	25.00
Benue	1,198,680	548	0.46	29	25.00
Borno	1,589,400	883	0.56	39	25.00
Cross river	650,128	445	0.69	16	25.00
Delta	1,145,787	325	0.28	28	25.00
Ebonyi	637,375	194	0.31	15	25.00
Edo	106,335	26	0.25	2	25.00
Ekiti	325,939	190	0.58	8	25.00
Enugu	770,522	209	0.27	19	25.00
FCT-Abuja	245,440	77	0.32	6	25.00
Gombe	601,375	184	0.31	15	25.00
Imo	195,075	76	0.39	4	25.00
Jigawa	1,060,396	513	0.48	26	25.00
Kaduna	1,248,819	408	0.33	31	25.00
Kano	1,729,744	513	0.30	43	25.00
Katsina	1,405,492	595	0.42	35	25.00
Kebbi	750,452	464	0.62	18	25.00
Kogi	756,733	465	0.62	18	25.00
Kwara	323,549	141	0.44	8	25.00
Lagos	343,028	37	0.11	8	25.00
Nasarawa	457,742	352	0.77	11	25.00
Niger	1,098,726	405	0.37	27	25.00
Ogun	515,463	152	0.30	12	25.00
Ondo	828,557	266	0.32	20	25.00
Osun	457,604	168	0.37	11	25.00
Oyo	865,891	292	0.34	21	25.00
Plateau	829,789	394	0.48	20	25.00
Rivers	797,321	258	0.32	19	25.00
Sokoto	1,026,713	585	0.57	25	25.00
Taraba	910,651	683	0.75	22	25.00
Yobe	685,347	295	0.43	17	25.00
Zamfara	907,400	428	0.47	22	25.00
High	1,729,744	883	0.77	43	25.40
Average	769,229	333	0.43	19	25.01
Low	195,075	26	0.11	2	25.00

4.9 Development of GIS e-Maps

Results obtained from running different scenarios with the NP model was downloaded and used to create various maps with the aid of the ArcGIS 2010 software. Map of existing grid networks were obtained from the TCN, which was digitized and converted into a shape-file for the use of the Arc Map. The Nigerian states and Map was also digitized and converted to a shape-file to conform to the Arc Map format. The figure 4.3 below shows the base scenario of the results visualized in an Arc Map.

Figure 4.3: Map of Nigeria Showing Recommended Technologies-Base Scenario



The red dots show areas recommended for grid technology in Nigeria, the black dots show areas were mini-grid technology is least costly, while the brown stripes indicate existing grid network, and the blue stripes indicate the proposed grid network.

4.10 Sensitivity Analysis

A sensitivity analysis was carried out to determine how outcomes of the model may vary with changes in the different input parameters. A specific evaluation of how effects of changes in cost of solar panels, diesel fuel cost, household electricity demand and the mean inter-household distance (MID) affect the results of the model were done. Results of the sensitivity analysis show that outcomes are indeed sensitive to changes in the cost of solar panels, diesel fuel cost, households demand and MID as discussed below.

4.10.1 Effects of reduction in solar panels

A reduction in the cost of solar panels from US$2000/kW used in the base scenario to US$500/kW (assuming a drastic crash in the cost of solar panels based on the current decreasing market trend for solar panels) would make grid the least cost option for about 66% of the population, and off-grid, the least cost option for 34% of the population. Total cost (US$34.3 billion) is slightly lower than the base scenario of US$34.5 billion, levelized costs for grid and off-grid systems are US$0.28 and US$0.35 respectively. Table 4.11 below shows that while the total length of proposed LV lines remains the same as in the base case, proposed length of MV line if solar panel reduces to US$500 is 7,176,921 meters. This is lower than the base scenario length of 12,193,060 meters, due to more LGAs becoming off-grid compatible.

Table 4.11: Cost Summary Table for solar panel reduction to $500

	Total Number of Households Electrified (million)	% of Households Electrified	System Total Initial Cost (million $)	Initial Cost Per House-hold $	System Total Recurring Cost per Year (million $)	Recurring Cost per Household $	Leveli-zed Cost $	Proposed LV Line (million metres)	Proposed MV Line (million metres)
Grid LV + Transformer			15,826	843	6,899	368		711	7
Grid MV	18	66%	1,109	59	60	3			
Grid Total			16,936	903	6,959	371	0.28		
Mini-grid									
Off-grid	9	34%	8,833	909	1,603	165	0.35		
Grand Total	**28**		**25,769**	**905**	**8,562**	**301**			

Figure 4.4 below shows the household count by bin type. We observe that for LGAs with households ranging from 1 to 10,000, off-grid technology was recommended as the least-cost option, same for LGAs with population ranging from 10,001 to 25,000, and a part of LGAs with a population range of 25001 to 50000, and 50,001 to 100,000. However, LGAs with population of a 100000 and above all went for grid as the least cost option. This scenario is slightly different from the base scenario where populations from 50,001 and above all went for grid as the least-cost option.

Figure 4.4: Household Count by Bin Type (Solar Panel $500)

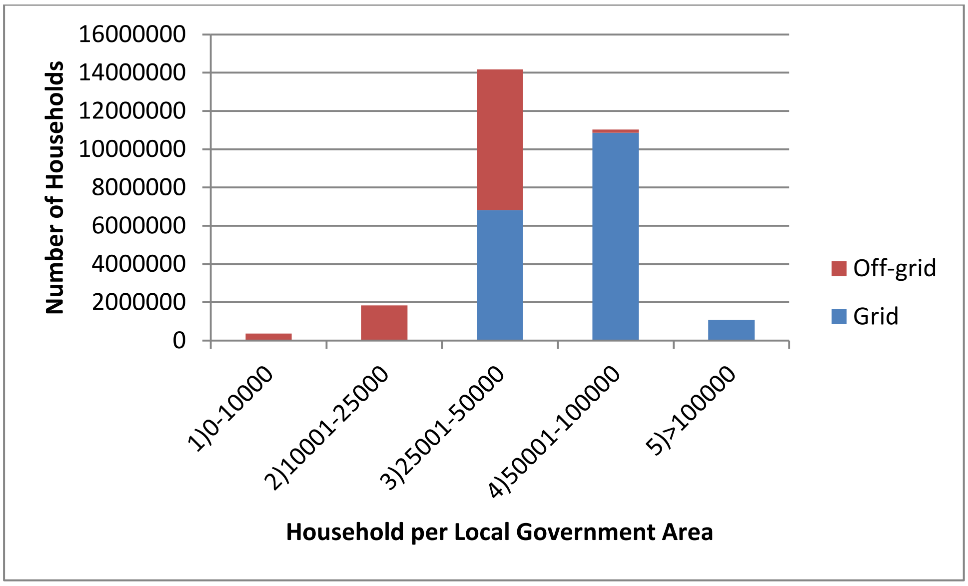
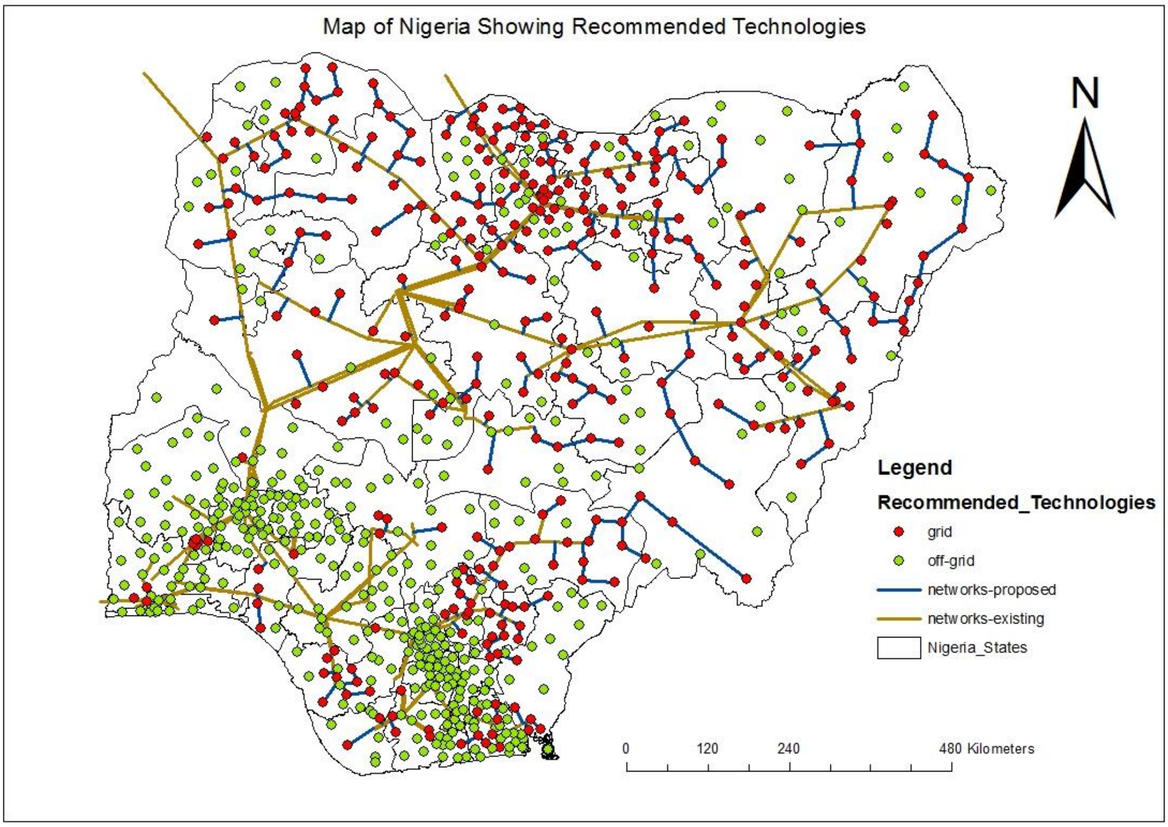


Figure 4.5 below shows the map of Nigeria with the recommended technologies in various states in Nigeria when the cost of solar panels reduces from US$2,000/kW to US$500/kW. It was drawn with the aid of the ArcGIS map 2010.

Figure 4.5: Map of Nigeria Showing Recommended Technologies- $500 Solar



4.10.2 Effects of changes in diesel fuel cost

Reducing the pump price of diesel fuel from US$0.96 to US$0.65 in this scenario based on projected improvement in diesel refining capacity in Nigeria and diesel availability at competitive market price when Dangote Group's 400,000 barrels a day refining capacity eventually comes up in 2016, results in a significant shift in the population covered by the diesel mini-grid system. Table 4.12 below shows that other variables remaining equal, the grid compatible population reduces from 98% in the base scenario to 51% when diesel price alone is reduced to US$0.65, while the mini-grid population increases to 49% from 2% in the base scenario. This is due to affordability of the mini-grid system as diesel price which is a major input is reduced drastically, as more LGAs are now able to afford it.

We also observe a reduction in MV line length to 3,450,760 metres compared to the base scenario, as well as a lower levelized cost, and total initial cost. However, the total recurring cost in this scenario is higher than the base scenario; this may not be unconnected with the purchase of diesel on a regular basis for the mini-grid system.

Table 4.12: Cost Summary table for reduction of diesel cost to $0.65

	Total Number of House-holds Electrified (million)	Percentage of Households Electrified	System Total Initial Cost (million $)	Initial Cost Per Household $	System Total Recurring Cost per Year (million $)	Recurring Cost per Household $	Leve-lized Cost $	Proposed LV Line (million metres)	Proposed MV Line (million metres)
Grid LV + Transformer			12,385	845	5,458	372		711	3
Grid MV	14	51%	452	31	3,788	258			
Grid Total			12,838	876	9,246	631	0.28		
Mini-grid	13	49%	11,354	822	3,565	258	0.34		
Off-grid	-								
Grand Total	**28**	**100%**	**24,192**	**850**	**12,811**	**450**			

We observe from figure 4.6 below that more household bins (0 – 100,000) now use the mini-grid system, as opposed to the base scenario where only household bins from 0 to 25,000 only used mini-grid. It goes to show that affordability of any technology is a major factor in determining the number of households that will embrace a rural electrification technology option.

Figure 4.6: Household Count by Bin Type (diesel $0.65)

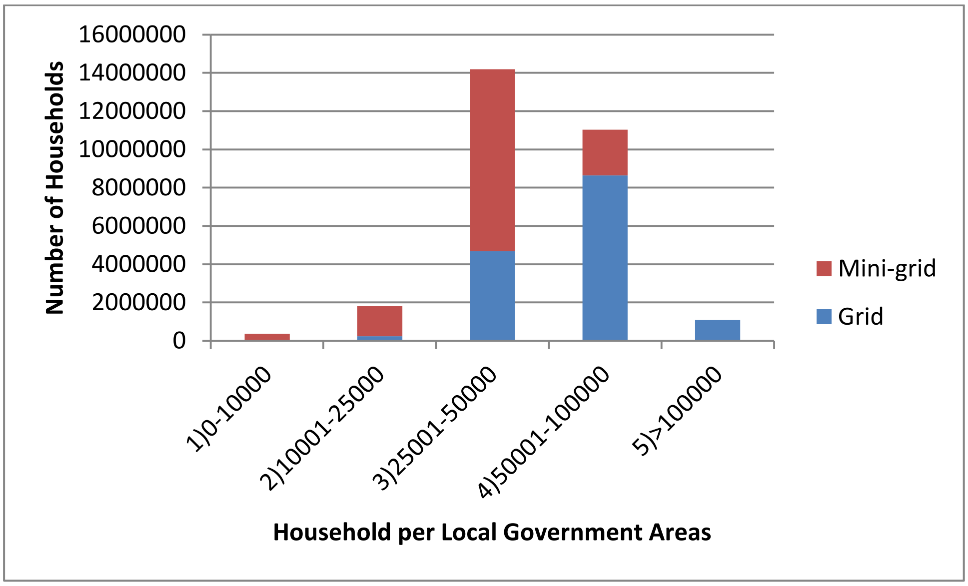
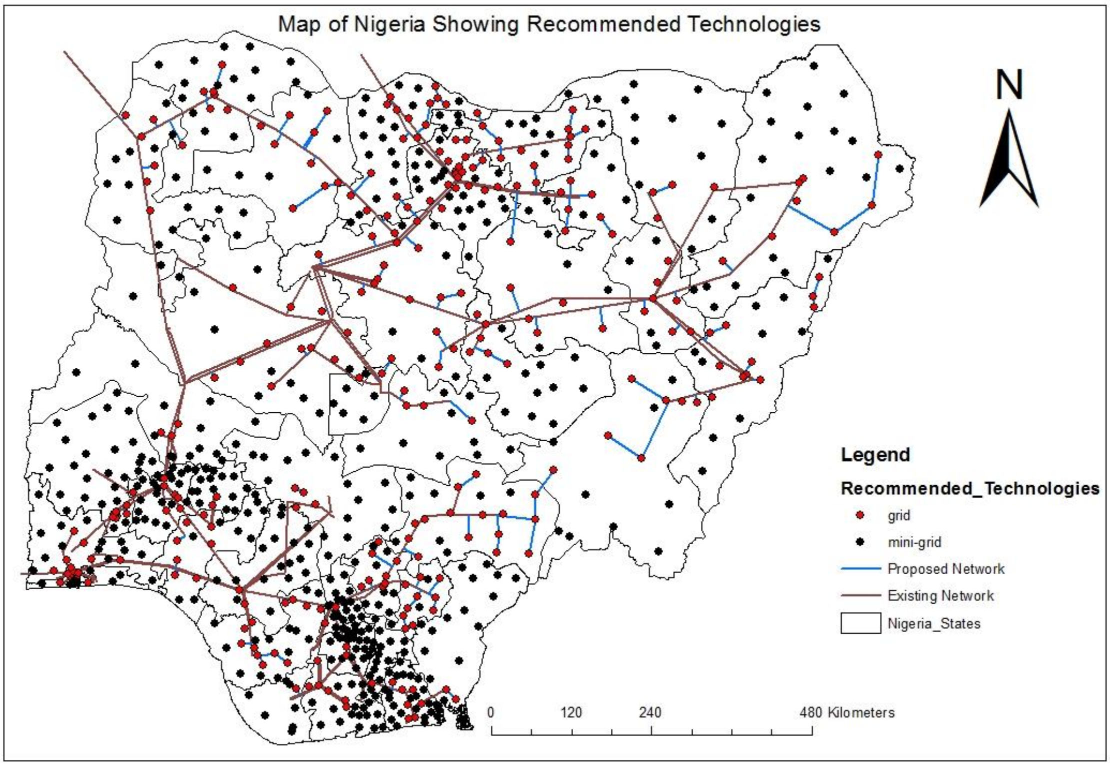


Figure 4.7 below shows the map of Nigeria and recommended technologies when diesel price is reduced. We observe that the red and black dots are now almost evenly spread around the country when compared to the base scenario that had the red dots spread almost in all parts of the country.

Figure 4.7: Map of Nigeria Showing Recommended Technologies- diesel at $0.65



4.10.3 Effects of Simultaneous Change in Solar Panels and Diesel Fuel

From the preceding scenarios, we have seen the effect of a reduction in solar panels alone as well as a reduction in diesel fuel price alone. In this scenario, a simultaneous reduction in solar panels to US$500 and diesel fuel price to US$0.65 results in a fairly balanced allocation of population for each technology option. Under this scenario, 46% of the population would be supplied by the grid as the least cost option, 24% of the population would be served via mini-grid as the least cost option, while 30% would be served with off-grid technology option as the least cost. Table 4.13 below shows that the levelized costs for grid and mini-grid are also lower compared to the base scenario, as well as the system total initial cost and recurring cost. The table also shows that while total proposed LV line length remained unchanged, the total proposed MV line length in this scenario is significantly lower than the base scenario from 12,193,060 metres to 3,271,686 metres.

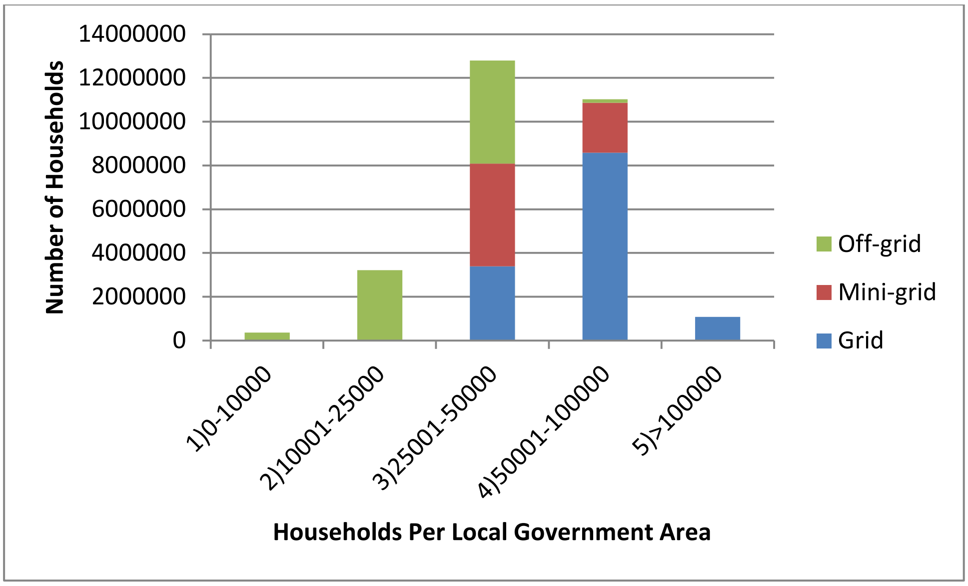
Table 4.13: Cost Summary Table for reducing solar panel cost to $500 and diesel fuel cost to $0.65

	Total Number of Households Electrified (million)	Percentage of Households Electrified	System Total Initial Cost (million $)	Initial Cost Per Household $	System Total Recurring Cost per Year (million $)	Recurring Cost per Household $	Leve-lized Cost $	Proposed LV Line (million metres)	Proposed MV Line (million metres)
Grid LV + Transformer			11,112	851	5,133	393		711	3
Grid MV	13	46%	435	33	27	2			
Grid Total			11,548	884	5,161	395	0.27		
Mini-grid	7	24%	5,965	857	2,177	313	0.31		
Off-grid	8	30%	7,405	876	1,312	155	0.35		
Grand Total	**28**	**100%**	**24,919**	**875**	**8,651**	**304**			

Figure 4.8 depicts this scenario in a graph. The picture shows a diversified electrification technology base where the lower household bins range of 0-25,000 is wholly off-grid, LGAs with population of 25,001-50,000 are fairly

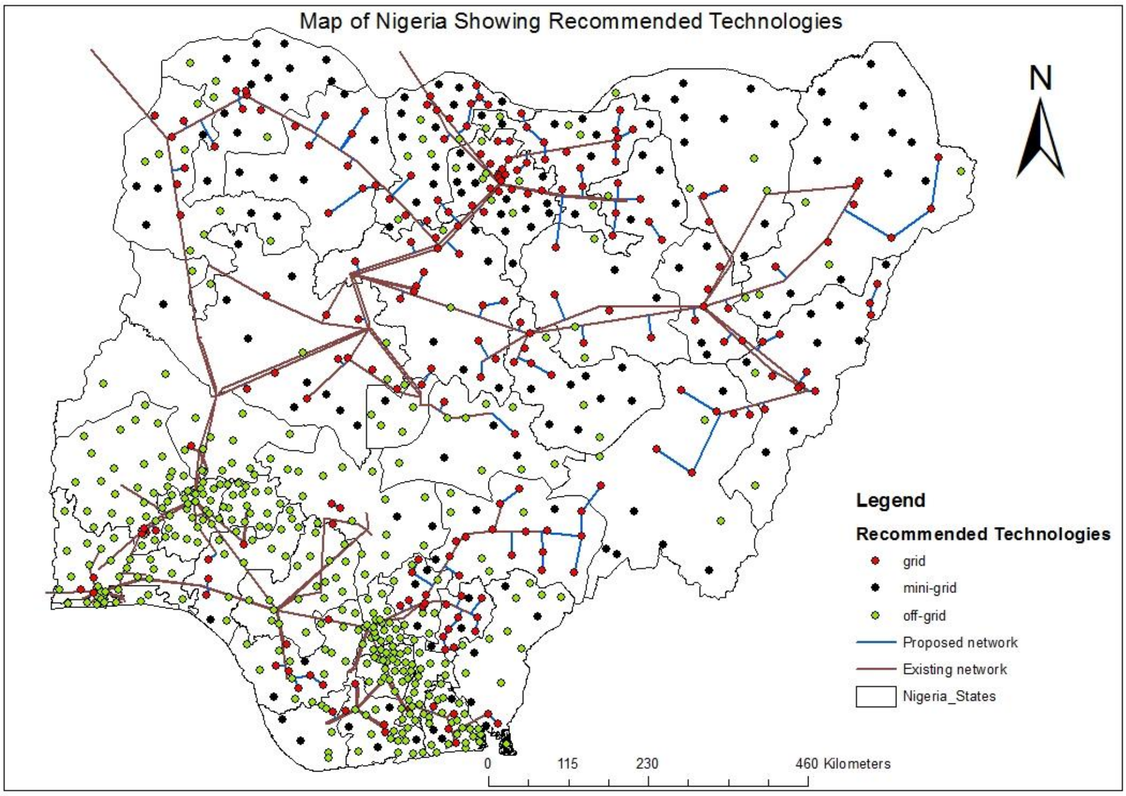
diversified in terms of technology choice (off-grid, grid and mini-grid), and the upper households have more of grid and mini-grid.

Figure 4.8: Household Count by Bin Type (solar $500 & diesel $0.65)



The map of Nigeria in figure 4.9 below shows the recommended technologies by regions. The off-grid LGAs as seen in the map are more concentrated in the South-West and South-South of the country, while the mini-grid option is more cost effective in the North-West and North-East. The grid system is spread all over the country, but with particular presence in the North.

Figure 4.9: Map of Nigeria Showing Recommended Technologies-solar at $500 & diesel at $0.65



4.10.4 Effects of changes in household demand

An increase in demand from 330kWh in the base scenario to 400kWh makes the grid system the least cost option for about 99% of the population, with the remaining 1% going for diesel mini-grid. Under this scenario, there is no off-grid recommended option due to the increase in household electricity demand. The grid system seems to be more viable for communities with high demand and population compared to sparsely populated areas which traditionally are off-grid compatible.

When household demand increases to 400kWh, total MV line length increases from 12,193,060 meters to 12,662,177 meters. The increase is attributed to connection of more LGAs to the grid as compared to the base scenario. On the whole, we observe that while an increase in demand leads to the connection of more LGAs and promotes access, it also increases initial and recurring costs, though not proportionate when compared to the base scenario. Table 4.14 gives more details.

Table 4.14: Cost Summary Table when demand increases to 400kWh

	Total Number of Households Electrified (thousand)	Percentage of Households Electrified	System Total Initial Cost (million $)	Initial Cost Per Household $	System Total Recurring Cost per Year (million $)	Recurring Cost per Household $	Leve-lize d Cost s $	Proposed LV line (million metres)	Proposed MV Line (million metres)
Grid LV + Transfor mer			23,776	844	10,408	369		711	12
Grid MV	28,173	99%	2,083	74	105	4			
Grid Total			25,859	918	10,514	373	0.28		
Mini-grid	305	1%	241	790	87	286	0.45		
Off-grid									
Grand Total	**28,478**	**100%**	**26,101**	**917**	**10,602**	**372**			

Figure 4.10 below shows that when demand increases, more households become grid compatible, even households between 0-10000 that all went mini-grid or off-grid in other scenarios.

Figure 4.10: Household Count by Bin Type (demand 400kWh)

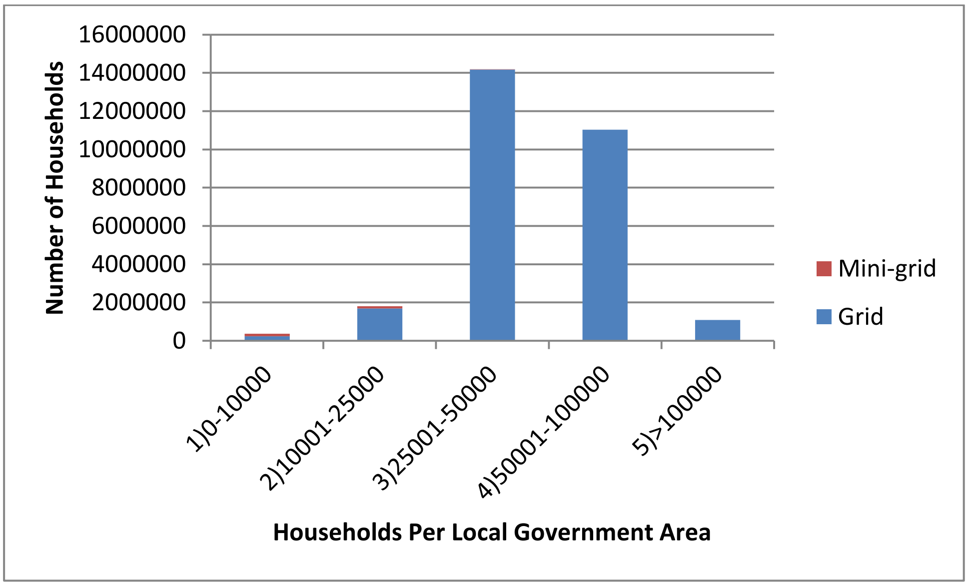
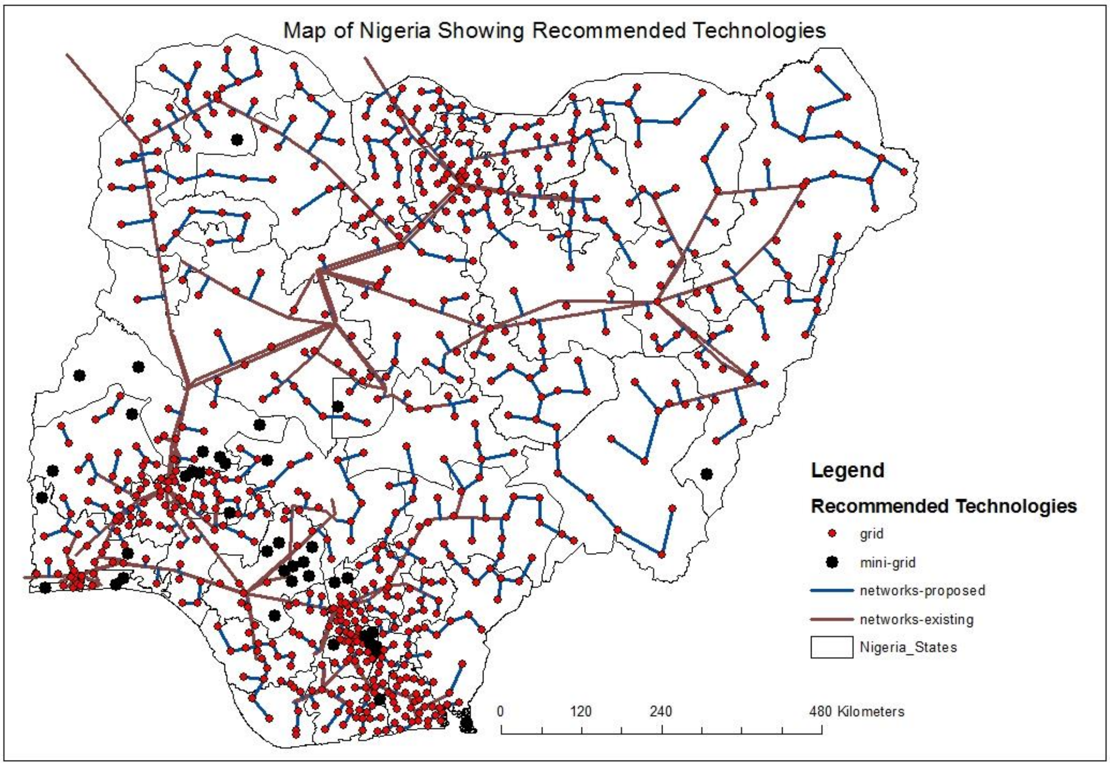


Figure 4.11 depicts this scenario in Nigeria's map. The red dots represent the grid LGAs while the Black ones denote the mini-grid LGAs.

Figure 4.11: Map of Nigeria Showing Recommended Technologies-demand at 400kWh



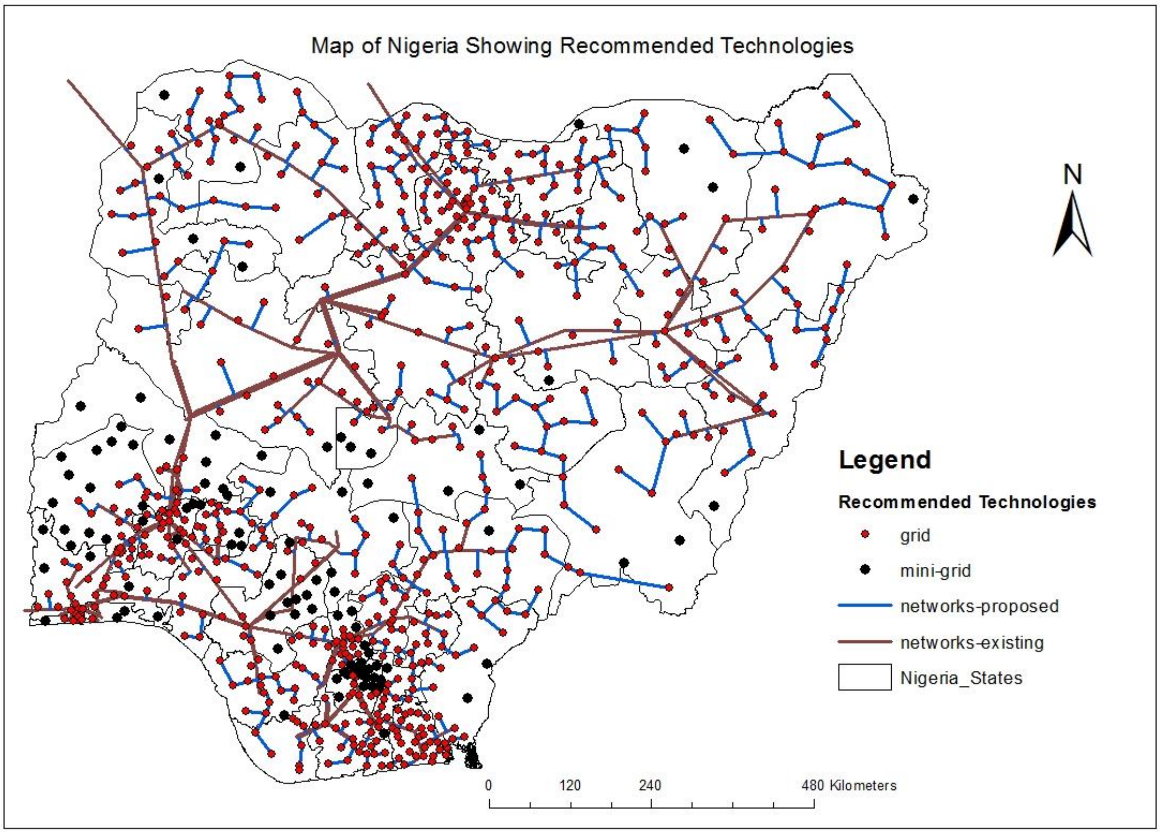
On the other hand, when electricity demand reduces from 330kWh in the base scenario to 250kwh in this scenario, naturally, less LGAs become grid compatible as observed in the decrease from 98% in the base scenario to 95% in this scenario. Table 4.15 below shows that costs are reduced under this scenario, as well as MV line length. However, the levelized costs under this scenario are higher as seen in table 4.15 below.

Table 4.15: Cost summary table when demand reduces to 250kWh

	Total Number of Households Electrified (million)	Percentage of Households Electrified	System Total Initial Cost (million $)	Initial Cost Per House-hold	System Total Recurring Cost per Year (million $)	Recurring Cost per Household	Leve-lised Cost	Proposed LV line (million metres)	Proposed MV line (million metres)
Grid LV + Transformer			21,866	810	6,790	251		711	11
Grid MV	27	95%	1,808	67	93	3			
Grid Total			23,674	877	6,883	255	0.33		
Mini-grid	1	5%	1,114	758	312	213	0.52		
Off-grid									
Grand Total	**28**	**100%**	**24,789**	**870**	**7,196**	**253**			

Figure 4.12 shows the map of Nigeria and recommended technolgies when demand is reduced from 330kWh to 250kWh.

Figure 4.12: Map of Nigeria Showing Recommended Technologies-demand at 250kWh



4.10.5 Effects in Changes in Mean inter-household distance (MID)

An increase in mean inter-household distance (MID) tends to swing un-electrified households to become off-grid compatible, while a reduction in MID makes un-electrified communities to be mini-grid and grid compatible. From table 4.16 below, it is noted that when MID is increased from 25metres in the base scenario to 200meters, it displaces the mini-grid compatible communities completely and replaces a large percentage of grid compatible households such that 56% of the population now prefer off-grid technology and the least cost option, and 44% stick with the grid.

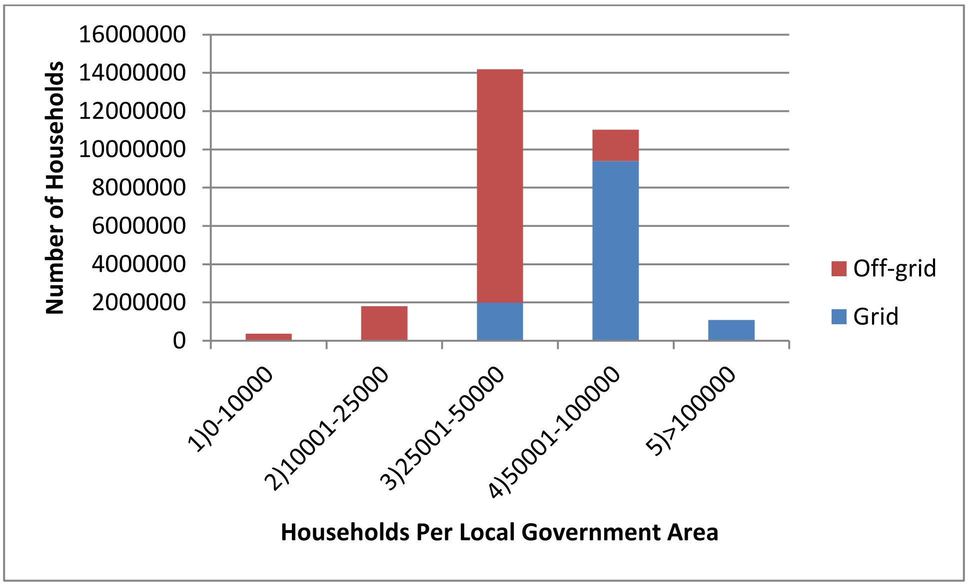
Although total initial and recurring costs increased astronomically, as well as levelized costs and proposed LV line length when compared with the base scenario, the MV line length reduces from 12,193,060m in the base scenario to 4,874,440m in this scenario.

Table 4.16: Cost Summary table when MID increases to 200m

	Total Number of Households Electrified (million)	Percentage of Households Electrified	System Total Initial Cost (million $)	Initial Cost Per Household $	System Total Recurring Cost per Year	Recurring Cost per Household $	Leve-lized Costs $	Proposed LV Line (million metres)	Proposed MV line (million metres)
Grid LV + Transformer	12	44%	47,813	3,833	7,455	598		5,695	4
Grid MV			758	61	40	3			
Grid Total			48,572	3,894	7,496	601	0.62		
Mini-grid									
Off-grid	16	56%	43,749	2,733	5,733	358	0.80		
Grand Total	**28**	**100%**	**92,321**	**3,242**	**13,230**	**465**			

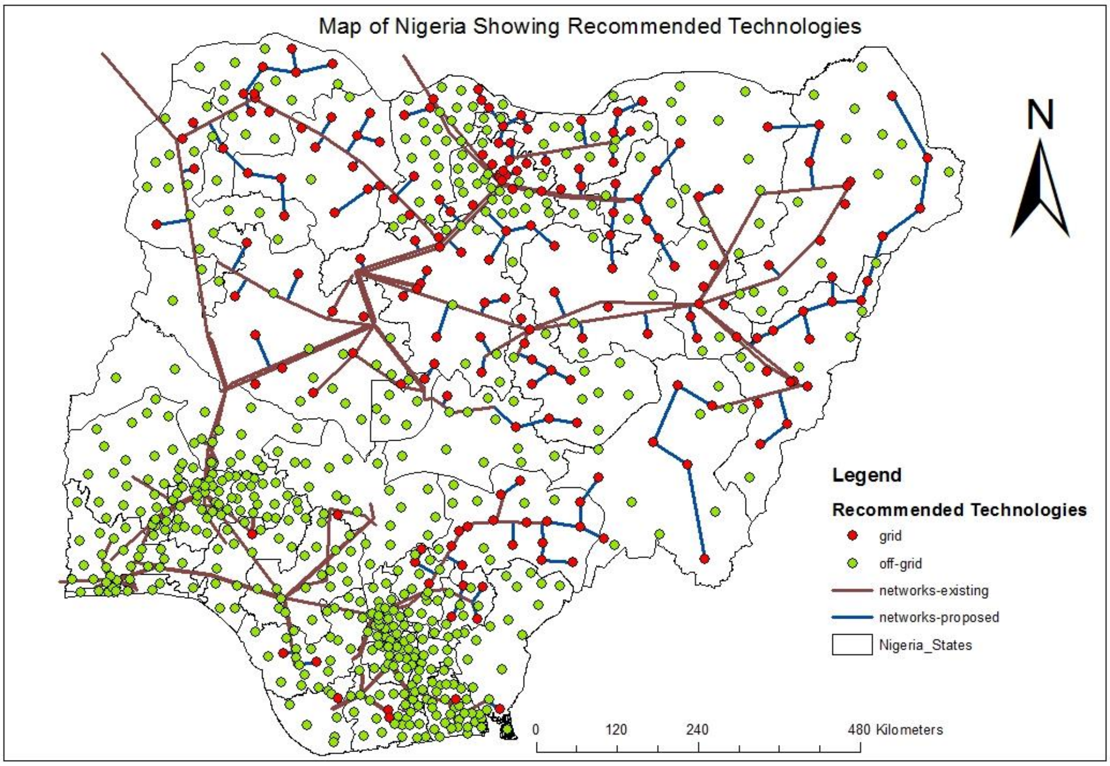
Figure 4.13 below shows that household's population bins between 0-10,000, 10,001 to 25,000 all went completely off-grid. A major part of households between the range of 25,001-50,000, and a small part of bins 50,001-100,000 also went off-grid under this scenario, while the remaining part of the household bins 25,001 and 50,000, 50,001-100,000 as well as all of 100,000 and above were grid compatible.

Figure 4.13: Household Count by Bin Type (MID 200m)



The map of Nigeria showing various technologies under this scenario is depicted in figure 4.14 below. We observe that most of the communities are off-grid compatible as represented by the green dots spread all over, while the rest are grid based, as depicted by the red dots.

Figure 4.14: Map of Nigeria Showing Recommended Technologies-MID at 200m



4.11 Comparison of Results with Other Studies

Table 4.17: Base Scenario Result comparison with other Studies

Country	Total Number of Households Electrified	Costs of Electrification (US$)		Length of Proposed MV Lines (Metres)		Length of Proposed LV Lines (Metres)	
		Total (million $)	Per HH $	Total (million metres)	Per HH	Total (million metres)	Per HH
Nigeria	28,478,962	34,540	1,212	12	0.4	712	25.0
Ghana	284,147	591	2,082	7	26.2	7	24.4
Senegal	134,448	140	1,048	3	27.5	3	24.0
Kenya	8,700,000	13,502	1,552	-	-	-	-
High	28,478,962	34,540	2,082	12	27.5	712	25.0
Average	9,399,389	12,193	1,474	7	18.0	240	24.0
Low	134,448	140	1,048	3	0.4	3	24.0

Table 4.17 above uses the household as the unit of comparison between the results of our base scenario and case studies of Ghana (Kemausor et al. 2012), Senegal (Sanoh et al. 2012) and Kenya (Pali et al. 2009). Summary of results from the table reveals that while an estimated 28.5 million households will be electrified in Nigeria, representing the highest, the average number of households electrified from the table is 9.4 million, while Senegal has the least number of 134, 500 households electrified.

Consequently, Nigeria will require approximately US$34.5 billion to electrify the aforementioned households between 2013 to 2030, while Ghana requires US$592 Million between 2010 and 2020 to electrify 284,000 households, Senegal needs US$150 million for 134,500 households in 10 years, and Kenya requires US$13.5 billion for a full penetration and electricity access investment for 8.7 million people between 2007 and 2017.

Average total electrification cost for the four countries compared is US$12.2 billion, while the least was US$150 million for Senegal. The variance in costs are attributed to the different time horizons used for various studies, as well as differences in population, household numbers, costs of various technology components and cost of diesel fuel.

However, in terms of per household costs, Ghana takes the lead with US$2,082, followed by Kenya at US$1,552, Nigeria with US$1,212 and the lowest being Senegal at US$1,048. Several factors such as population and number of households may be reasons attributable for the discrepancies.

For total length of proposed MV and LV lines, the table also reveals that Nigeria requires the highest, while Senegal requires the least. Although the per household costs vary, as more lengths of MV Lines are required for Senegal and Ghana when compared with Nigeria, while an average of 24m of LV line length is required for all the countries compared.

4.12 Model Limitations

While the NP model has been an effective tool for electrification planning at continental, national and local levels, it has some limitations as listed below:

- The NP model is currently limited to three technologies (grid, off-grid solar PV and Mini-grid diesel generator). Although other renewable technologies such as hydro could be incorporated, this will involve a technical programming knowledge, which is a specialized skill.
- While the model makes use of cost assumptions based on the best available data, it does not take into consideration the constantly changing nature of costs brought about by economic and technological changes. The assumption that all cost conditions remain unchanged throughout the planning period is not obtainable in reality.
- Costs do not include the technical and geographical constraints of connecting communities, such as hilly terrains, flat-lands, major roads etc. This could increase total capital cost if taken into consideration.
- Generation cost for the grid technology is also not incorporated.

Notwithstanding the aforementioned limitations, the NP model was very useful as a preliminary means of assessing costs of different electrification scenarios in Nigeria.

4.13 Summary

The Network Planner (NP) model applied in this research is useful in electricity planning by decision makers, especially in the area of investment cost estimates and least cost technology options required for electrification purposes. Through a blend of demographic data, geographical information, current diesel prices, costs of solar components and so on, it becomes possible to estimate and map the economic potential of different technology options for rural electrification in Nigeria. More so, within a specific planning period, planners can determine with the aid of this model, communities that would become grid, off-grid or mini-grid compatible, either at local or national levels based on available data.

Results from this research shows that by the end of the seventeen year planning period (2013-2030), 98% of currently un-electrified communities will be viable for grid expansion, while only 2% will be mini-grid compatible. This is based on a proposed MV line extension of 12,193,060m, LV line length proposal of 711,954,700, and an estimated total cost of US$34.6 billion investment within the planning period. An estimated 28.5million households or an equivalent of 125million people are projected to be provided electricity access by the end of the planning period in 2030. The off-grid technology seems to be unviable given the base scenario parameters and time horizon.

However, a sensitivity analysis carried out shows that the different input variables have various levels of influence on the total cost and technology options. For instance, a decrease in the cost of solar makes more communities to swing to off-grid compatibility even though the base scenario does not favour an off-grid technology option.

It is also noted that reducing household demand though reduces the overall cost of electrification, but does not have too much effect on the number of households that become mini-grid compatible when compared to the drastic influence of other scenarios.

Furthermore, increasing the mean inter-household distance (MID) tend to shift more LGAs in Nigeria toward off-grid compatibility, since the households become sparse and farther from each other. Whereby, lowering the MID makes communities more grid-compatible. The MID was also observed to be the only variable that has effect on LV line length for connecting various households when it changes.

The first two research questions of this research are;

- What combination of Grid, Mini-grid and Off-grid electricity supply options should Nigeria adopt in providing universal electricity access to her diverse rural areas by 2030?

- What is the investment requirement towards achieving universal electrification in Nigeria by 2030?

In line with the aforementioned questions, results from the application of the model and its analysis, have answered the first two questions of this research. The third research question has to do with financing options for rural electrification in Nigeria, and is addressed in chapter five.

CHAPTER FIVE
FINANCING OPTIONS AND MODELS FOR RURAL ELECTRIFICATION IN NIGERIA

5.1 Introduction

Chapter three of this thesis provided a review of the enormity of energy access challenge in the world, with particular emphasis on funding rural electrification in developing countries, and the overall investment needs required to achieve 'energy for all' in 2030 (WEO, 2011). The funds are expected to come from different sources (private sector, bilateral assistance, governments of developing countries and multilateral institutions). However, current and past efforts to galvanise these sources to fund energy supply to the rural poor, has been inadequate to stem the tide. Unless and until new sources and models of financing rural electrification and energy access in developing countries such as Nigeria are developed and deployed, the status quo will continue (IEA, 2011).

Chapter four of this study presents an estimate of US$34.5 billion, being the cost required to extend electricity access to all the areas currently without access in Nigeria between 2013 and 2030. No doubt, this is an enormous amount that requires concerted efforts, policies, models and innovative ways to attract for the purpose of investing in rural electrification in Nigeria. Therefore, there is the urgent need for financing options for the estimated investment needs of US$34.5 billion for rural electrification in Nigeria to be developed and implemented, towards achieving the 'energy for all' goal of the Federal Government of Nigeria by 2030. This implies providing electricity to 28.5 million households or 125million Nigerians.

The aim of this chapter is to answer the third research question and objective, which is to determine the appropriate financing options/strategies required based on the cost estimates provided in chapter four, towards achieving universal electricity access in Nigeria by 2030. To do this, we rely on our review of financing options in chapter three, results derived from the spatial analysis carried out in chapter four, lessons from the rural electrification experiences of other countries, interviews conducted with stakeholders in Nigeria provided in 5.2 below, logical assumptions based on the realities of the Nigerian demographic/diverse characteristics, and on-going electricity sector reforms in Nigeria.

5.2 Outcome of Interview with Stakeholders in Nigeria

For feedbacks based on results of the analysis done in chapter four, as well as seek expert opinion on the subject-matter of financing rural electrification in Nigeria, an interview was conducted with stakeholders within the Nigerian Electricity Supply Industry and other experts outside Nigeria. A copy of the questionnaire used for this interview is attached in Appendix 3. However, a summary of the questions are:

A) BACKGROUND INFORMATION

1. Name
2. Company/Agency
3. Position

B) TECHNICAL INFORMATION

4. Have you or your company/agency ever conducted any technical study/survey to determine appropriate technology choices or combination of technologies to be used in generating/supplying electricity for rural electrification in Nigeria?

Yes [ ] No [ ]

5. If yes, what were your findings? If No, go to question 7.

6. What methodology/model was employed?

C) COSTS INFORMATION

7. Have you or your agency/company conducted any study to determine the cost of expanding energy access to areas that currently do not have access at any level (village, ward, state or national) in Nigeria?

Yes [ ] No [ ]

8. If yes, what were your findings? If No, go to question 10.

9. What methodology/model was employed?

D. BARRIERS

10. In your opinion and given your experience within the industry, what do you think are barriers to rural electrification in Nigeria?

E. FINANCING OPTIONS

11. In your opinion and given your experience within the industry, what would you proffer as financing options for rural electrification in Nigeria?

It was imperative to have this interview with the industry stakeholders to discuss topical issues related to rural electrification in the country, towards having an insight into the reality on ground through the lenses of the practitioners, policy makers, other stakeholders and executives of rural electrification in Nigeria. The interviews gave the researcher an idea of the direction towards which rural electrification in Nigeria is moving, as well as plans, policies, barriers and challenges of rural electrification in the country, based on current realities.

The interview was conducted with the following stakeholders:

i. Engineer Kenneth Achugbu, Managing Director of the Nigerian Rural Electrification Agency (REA). Date of Interview: 12th of February, 2014. Type of Interview: Face-to-face; Location: REA headquarters, Abuja, Nigeria.

Summary of Findings:

The MD of REA confirmed during the interview that the REA has not conducted any technical and/or costs study on appropriate technology options (grid, off-grid, and mini-grid) for rural electrification, as well as cost estimates for rural electrification expansion in Nigeria. Thus, he was enthusiastic about the objectives of this PhD research and its expected outcome. The MD also stated as a major barrier to rural electrification in

Nigeria; funding, and the overbearing interference of politicians in the activities of REA. The lack of implementation was also attributed to the interference from politicians and the policy of the FGN to return monies unused for projects they were budgeted for in a financial year.

The MD also confirmed that due to lack of an official Rural Electrification Strategy and Implementation Plan (RESIP) and Master-plan, the REA is unable to productively engage multilateral and bilateral agencies and other funding sources for collaborations. He listed Public-Private Partnerships, prioritization of projects based on areas of need, privatization, and competitive procurement bidding with transparency and strict qualification criteria as some possible remedies to financing rural electrification in Nigeria. He also believes that the draft RESIP and Master-plan would be approved and made official soon.

ii. Mallam Yusuf Abdul Salam, Senior Manager-Rural Electrification and Renewable Energy, Nigerian Electricity Regulatory Commission (NERC). Date of Interview: 25th of February, 2014; Type of Interview: Face-to-face; Location: Ajuji Hotel, Abuja, Nigeria.

Summary of Findings:

Yusuf talked about all efforts being put in place by NERC to develop the draft RESIP in conjunction with REA, which is now being reviewed as at April 2014. He also gave researcher a copy of the draft RESIPS, which has been a very useful document for this research. He confirmed there is no cost and technical study for rural electrification by NERC so far, and finds this PhD research very relevant and timely. Mr Yusuf believes there should be more options for rural electrification other than grid extension, and thinks the REF can be used judiciously to promote investments in rural electrification via PPP and subsidies using the Power Consumer Assistance Fund.

For other models that could work, he believes in tying a rural electrification project to a productive activity, which will serve as the base load for the project and the excess generation can go to the surrounding rural areas. He also believes in involving communities and stakeholders in rural electrification projects to give them a sense of ownership.

iii. Mallam Abdulkarim M.H., Principal Manager, Operations and Maintenance, Kano Distribution Company (DisCo), and Mallam Bashiru Hassan, Regulatory and Compliance Officer, Kano DisCo. Date of Interview: 11th of February, 2014; Type of Interview: Face-to-face; Location: Transcorp Hotel, Abuja-Nigeria.

Summary of Findings:

Kano state, which is in the Northern part of Nigeria and has the highest number of households without access based on the analysis from chapter four, should embark on more off-grid rural electrification projects according to the Kano DisCo representatives interviewed. They have their reservations about grid extension without commensurate generation increase especially in Northern Nigeria, and believe that the abundant renewable potential of Northern Nigeria can be used for off-grid projects to complement the DisCo's efforts. They suggested Solar PVs, Biogas and SHS renewable options on a PPP basis between the FGN, State governments and the DisCos.

They do not have any cost estimates for expanding electricity access to rural areas in their coverage area (Kano DisCo covers three states: Katsina, Jigawa and Kano), as well as any technical study on choice of grid or off-grid. They believe this research is very relevant.

iv. Engineer Dada M.N.O., Assistant General Manager-Transmission Service Provider (TSP). Date of Interview: 11th of February, 2014; Type of Interview: Face-to-face; Location: Transcorp Hotel, Abuja-Nigeria.

Summary of Findings:

Engineer Dada confirmed there is a technical study on expanding transmission lines over the next five years developed by the System Operator. The study is based on load/demand forecast and would cost USD$1.5 Billion yearly over the next 5 years. However, he was not able to make the study available to researcher for confirmation, and directed researcher to another department, which also did not yield any result.

He believes in a PPP model for funding rural electrification in Nigeria, which should not be cast in stone. He advocated collaborations with Multilateral and Bilateral agencies, as well as the private sector as a financing model. He opines that funding, and the ability to recoup investments as the major barriers of rural electrification in Nigeria.

v. Engineer Chris Chikezie, *PhD*, Assistant General Manager, Transitional Electricity Market (TEM), System Operation (SO), Transmission Company of Nigeria (TCN). Date of Interview: 11th of February, 2014; Type of Interview: Face-to-face; Location: Transcorp Hotel, Abuja-Nigeria.

Summary of Findings:

Dr Chris also confirmed that the TCN had a study on technical expansion and cost estimates based on demand/load forecast, but did not have access to it. He equally directed researcher to the Director of TSP at the headquarters of TCN, which researcher tried to reach to no avail. He believes this PhD study is very relevant and timely, and opines that funding should be based on PPP (FGN, States, and DisCos).

For barriers to rural electrification in Nigeria, he listed; large and difficult topography of Nigeria, litigations and compensations, poor project management, and the lack of ringed transmission system in Nigeria.

vi. Dr Albert Okorogu, Senior Special Adviser to the Minister of Power on *'Operation Light-up Rural Nigeria'*. Date of Interview: 17th of February, 2014; Type of Interview: Face-to-face; Location: Transcorp Hotel, Abuja-Nigeria.

Summary of Findings:

Dr Albert who is in charge of the Ministry of Power's programme on 'Operation Light up Rural Nigeria' gave an insight into the financing of this programme. He said the pilot solar street lighting, SHS and Solar Mini-Grid commissioned in January 2014 at a rural community close to Abuja

(Durumi), was completely financed by the FGN. However, when asked if that financing option would be sustainable, he said plans are underway to involve the private sector, but did not say how this would be done. He says the study is very relevant and timely.

vii. Nicola Bugatti, Renewable Energy and Energy Efficiency TA, ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE). Date of Interview: 27th of February, 2014. Type of Interview: Skype video call; Location: Abuja/Cape Verde.

Summary of Findings:

Mr Nicola is very enthusiastic about the outcome of this PhD thesis, and is in discussion with my Supervisor for possible collaborations. He believes the study is not just relevant for Nigeria alone, but the West African region and other developing countries. ECREEE has carried out a mapping survey of potential areas for grid connected and off-grid solar photovoltaic options in the West African Region, but has not done a cost/investment requirement study for the region. Details of this study can be found at http://irena.masdar.ac.ae/?map=507 (last visited on the 3rd of March, 2014).

Mr Nicola talked about different projects that ECREEE is co-funding and partnering with other Multilateral and Bilateral agencies in the West African Region. ECREEE is looking at potential collaborations with REA for rural renewable energy projects in Nigeria as soon as the REM and RESIP are made official. He says that ECREEE is also interested in collaborating with NBET in developing a PPA that would lead to a grid-connected renewable energy project.

viii. Luis-Carlos Miro, Rural Electrification Advisor, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) - Nigerian Energy Support Programme (NESP). Date of Interview: 10th of March, 2014. Type of Interview: Face-to-face; Location: NBET office, Abuja-Nigeria.

Summary of Findings:

Mr Luis-Carlos currently works on the GIZ funded NESP. He finds this research useful for the GIZ's NESP and is interested in the final outcome. The GIZ is currently collaborating with NERC, REA and Ministry of Power to support the government in building capacity and funding some projects. Rural electrification is one of their core mandates. Mr Carlos said they want to introduce pilot rural electrification projects in 5 geopolitical zones in Nigeria and are looking for the most efficient ways to structure the model.

They are also collaborating with the NBET to develop a Power Purchase Agreement for grid-connected renewable energy projects. However, the lack of an official RESIP is a barrier to their involvement in rural electrification projects in Nigeria. They also do not have any study on costs/financing requirement and technical options study for rural electrification in Nigeria, but want to embark on such as soon as possible.

ix. Mr Omotayo Hassan, USAID Energy Finance Consultant with the Nigerian Bulk Electricity Trading PLC. Type of Interview: Face-to-face; Location: NBET office, Abuja-Nigeria.

Summary of Findings:

Mr Omotayo has been very useful in coming up with various financing options for rural electrification in Nigeria. Having identified funding and lack of political will as major barriers to rural electrification in Nigeria, he went ahead to suggest a PPP model where state governments in collaboration with GenCos and DisCos develop projects, where the states will guarantee the GenCos of their investments, and the DisCos off-take the energy, based on embedded generation of not more than 20MW. He believes the study is relevant and will lay a foundation for further studies in this area.

Conclusions from Interviews

From the foregoing, it is evident that rural electrification in Nigeria is an afterthought to the main electricity sector reforms currently going on in the country. This is so because of the limited efforts so far in terms of rural electrification in Nigeria, where there is still:

- No official Rural Electrification Strategy and Implementation Plan (RESIP);
- No official study or survey currently to determine those that do not have access to electricity in Nigeria;
- No clear-cut financing models that can work for rural electrification in Nigeria;
- No plans for prioritizing areas of need in terms of rural electrification; and
- No political will and commitment to drive the process.

This poses a paradox for the nation given the enormous potentials in terms of resources available for rural electrification in Nigeria. For this to change there is need for government to be committed and drive the process of rural electrification by first according it the seriousness and attention it deserves, adopting/approving the REM and RESIP, changing the status quo where rural electrification projects are used as constituency projects for politicians, carrying out a detailed spatial electricity planning study by building on the findings of this thesis, and leveraging on available government finance to mobilise more private/donor sources of finance.

5.3 Scenario Analysis

According to Strupeit and Peck (2008), scenarios are hypothetical and describe likely outcomes. They depict dynamic approaches that characterize sequences of events over a range of time. They entail the causal relationships of states, events, driving forces, consequences and actions, usually starting from an initial state of the 'present', then give a picture of an anticipated final state over a time horizon.

The importance of scenario analysis in planning cannot be over-emphasized. It helps in managing risks and uncertainties, aiding decision making, and creating a common vision. They do not try to provide answers to every likely outcome of a process, but rather give an insight towards exploring change processes.

In order to achieve the goal of universal electrification in Nigeria by 2030, various rural electrification funding pathways are necessary to help policy-makers and investors make informed decisions as well as aid with planning. To that end, this study develops two simple scenarios against the backdrop of Nigeria's draft Rural Electrification Strategy and Implementation Plan (RESIP) which describes the business as usual scenario, and results from the Network Planner analysis in chapter four, which presents an alternative scenario.

The aforementioned scenarios were adopted to keep the analysis simple and transparent. For the purpose of answering the third research question; (how can the required investments in providing universal energy access in Nigeria be financed?), it is necessary to first look at how rural electrification is currently funded in Nigeria, as well as the government's plans for funding rural electrification going forward, to determine if this will be sufficient to meet the 2030 target or not. It is also important to present an alternative scenario which answers the third research question of this research based on cost estimates derived from the Network Planner analysis carried out in chapter four (4), and how alternative funding options and models can be used to achieve the universal electrification goal of Nigeria in 2030. Thus, funding under the NP scenario addresses this.

5.3.1 Funding under the Business as Usual (BAU) Scenario

Current financing of rural electrification in Nigeria is based on the provisions of the Electricity Power Sector Reform Act (EPSRA) 2005. The EPSRA 2005 established a Rural Electrification Fund (REF) and an agency to manage the fund called Rural Electrification Agency (REA). The purpose of the REF shall be to promote, support and provide rural electrification programmes through public and private sector participation, and the objectives of the REF include:

i. Achieve more equitable access to electricity across the six geo-political zones;

ii. Maximize the economic, social and environmental benefits of rural electrification subsidies;

iii. Promote expansion of the grid and development of off-grid electrification; and

iv. Stimulate innovative approaches to rural electrification.

The Federal Government of Nigeria (FGN) under the draft Rural Electrification Strategy and Implementation Plan (RESIP) 2012 has a target of providing electricity access to 75% of the rural and urban population by 2020, which is estimated to cover 471,000 new households' connection yearly between 2007 and 2020, and will cost between 311 and 519 Billion Naira. To achieve universal electrification, the FGN intends to connect 519,000 households yearly between the year 2020 and 2040, at an estimated cost of N484 to N807 Billion Naira. The cost of running REA is estimated to be 23.4 Billion Naira for the period 2007 to 2020 and 80.2billion Naira for the period 2020 to 2040. Table 5.1 below depicts the investment requirement for rural electrification in the 'business as usual scenario'.

Table 5.1: Investment Requirement for Rural Electrification in the 'Business as Usual Scenario' 2007-2040

	2007-2020	2020-2040	Total
Projected penetration level	75%	remaining 25%	100%
Overall Investments ($ billion)	1.8-3.1	2.9-4.8	4.7-7.9
Annual Investment ($ million)	144-241	146-244	290-485
Rural households gaining access yearly (thousands)	471	513	984
Main source of funding	FGN	FGN	FGN
Other sources of funding	International donors, private sector, state and local governments	International donors, private sector, state and local governments	International donors, private sector, state and local governments

Source: Draft RESIP Nigeria 2012

Overall, the REA requires between 941 Billion Naira and 1.41 Trillion Naira ($4.7-7.9 billion)[69] in order to achieve universal electricity access from 2007 to 2040, based on REA estimation. This includes costs of running the REA and projects for expanding electricity access. However, to complete the over 1900 rural electrification projects started under the FMPS's NREP, the REA requires the sum of 44.8 Billion Naira.

To fund this investment, the REF was designed by the FGN via the EPSRA to pool funds together for rural electrification programmes from a combination of sources. The REF would receive as part of its assets and capital:

i. Any appropriated monies from the National Assembly yearly;
ii. Any surplus appropriated pursuant to section 53 of the EPSRA 2005;
iii. Any contributions made as provided by the EPSRA 2005, and interests and other benefits accrued to the Fund;
iv. Any fines obtained by NERC pursuant to the EPSRA 2005;
v. Such percentage of the annual turnover of the licence as may be determined by NERC; and
vi. Any donations/gifts, and loans made by international agencies, State Governments, the Federal Government, Local communities, businesses and other entities.

This will allow for availability of funds for rural electrification projects and eradicate the threat of abandoned or uncompleted projects due to lack of funds. However, the REF is not meant to be used as subsidies for consumption. Rather, another fund called the Power Consumer Assistance Fund (PCAF) will be set up by the NERC for the purpose of electricity subsidy for consumers.

Furthermore, to cover any deficit in the assets and capital of the REF, the EPSRA 2005, provides for the REA to liaise with NERC in determining

[69] This amount is four times lower than the NP model estimate of $34.5 billion obtained in chapter four. It is however unclear what methodology or costing model that was applied to arrive at the REA estimates, since it has been confirmed by various stakeholders in 5.2 that no such comprehensive cost studies have been carried out yet, which makes the REA estimates doubtful and unreflective of the enormity of lack of electricity access in various parts of Nigeria.

contribution rates to be sent to the REF by market participants. These market participants include but not limited to the following:

i. All licenses as may be determined by NERC which may include distribution companies (DisCos) and generation companies (GenCos);
ii. Eligible customers; and
iii. Consumers (other than the disadvantaged consumers whose access to power is meant to be assisted by the REF), on the Commission being satisfied that retail power tariffs for such consumers have reached a level where they reflect the cost of electricity.

Without depending on the aforementioned sources, the FGN will continue to fund Rural Electrification Projects in the short and medium terms and until such a time funds from other sources will be sufficient to finance rural electrification programmes without appropriation from the FGN. More so, the REA and FGN will put in more efforts towards attracting contributions from other sources such as bilateral and multilateral agencies, NGOs, lenders such as Commercial Banks, project sponsors, Development Banks, end-users, and other relevant stakeholders.

According to the draft RESIP, the Fund would be managed by the REF Department of Funds Directorate, consisting REA staff at Federal and Zonal levels functioning as a unit towards implementing the REP, subject to the REA Board's approval. In addition, guidelines for issuing various sizes of grants such as eligibility requirements, evaluation procedures and criteria are all under the responsibility of the REF department of Fund Directorate.

The following are the procedures set out in the draft RESIP for projects implementation under the REF:

i. Advertisement for expression of interest would be made in one international business journal and at least two (2) National

Newspapers, and applications from interested parties will be submitted to the Zonal offices or Headquarters of the REA;

ii. The entire applications received from all Zonal offices for the advertised REF projects shall be submitted to the REA Headquarters for scrutiny and to ensure that they meet the requisite eligibility criteria, which includes:
   - Demonstrated technical, economic and financial viability for a sustained period.
   - Demonstrated support for rural development, taking into account the priorities of the local communities.
   - The level of community and investor commitment to the proposed activity.

iii. Others may include, but not limited to:
   - Levels of Tariff
   - Quality of services
   - Documentations and requisite licenses to undertake such projects etc.

The REA as part of its proposed Rural Electrification Strategy and Implementation Plan (RESIP) will be able to carry out new and on-going projects, surveys, research, designs and consultancies necessary for rural electrification through the REF. However, such projects must be methodically appraised to meet the following values enumerated in the EPSRA 2005:

i. Viability: Economic and financial, with the initial capital subsidy;

ii. Investor commitment (i.e., significant capital investment);

iii. Promotion of social and economic objectives, (e.g., fair allocation of infrastructural investment across geopolitical zones and between populations of different income strata, service provision to a maximum of new consumers, and use of environmentally-sustainable energy sources);

iv. Choice of technology to be used, (e.g., preferential scoring of renewable RE projects);
v. Cost effectiveness (e.g., cost per connection, and long-term operation and maintenance costs); and
vi. Nature and extent of community support (e.g., consumer buy-in, ability and willingness to pay for services).

See appendix 4 for the table showing evaluation criteria for projects selection under the rural electrification scheme

Although the REA had its activities halted in 2009 due to allegations of corruption and mismanagement, it has since be restructured and re-opened since January 2012, and has initiated about 2000 rural electrification projects, a few of which have been completed and commissioned[70].

More so, various licenses have been given to different private companies and state governments to build power plants under the reform programme, and the Federal Government (FG) also, has gone into bilateral agreements and partnerships with some countries such as France and Japan[71] aimed at building new power sub-stations and transmission lines in Nigeria. Thus, there are various on-going power projects scattered around Nigeria, and it is hoped that the reforms will pay-off in due course.

According to the new Minister of Power-Professor Chinedu Nebo, over 10 billion naira was budgeted for rural electrification in the 2013 national budget of Nigeria, with 1946 on-going rural electrification projects across the country[72]. However, table 5.2 below shows that the REA received a total capital budget of 5.8 Billion Naira based on the budget breakdown obtained from the budget office. Further, in September 2013, there was an injection of 16 billion naira into the REA with the inauguration of its new supervisory board[73].

[70] *Ibid note 24*
[71] *Ibid note 13*
[72] See http://www.thisdaylive.com/articles/fg-earmarks-over-n10-billion-for-rural-electrification-in-2013/145689/
[73] Supra note 22

Table 5.2: 2013 Budget Summary of Ministry of Power

FEDERAL GOVERNMENT OF NIGERIA						
2013 BUDGET MINISTRY OF POWER						
CODE	**MDA**	**TOTAL PERSONNEL COST**	**TOTAL OVERHEAD COST**	**TOTAL RECURRENT**	**TOTAL CAPITAL**	**TOTAL ALLOCATION**
		=N= billion[74]	**=N= billion**	**=N= billion**	**=N= billion**	**=N= billion**
02310 01001	FEDERAL MINISTRY OF ENERGY (POWER) - HQTRS	0.789	0.531	**1.320**	23.505	**24.826**
23102 0001	**TRANSMISSION COMPANY OF NIGERIA (TCN)**	-	-	-	**33.850**	**33.850**
02310 03001	**NATIONAL RURAL ELECTRIFICATION AGENCY**	**0.589**	**0.061**	**0.650**	**5.806**	**6.456**
02310 04001	NIGERIAN ELECTRICITY REGULATORY COMMISSION	0.777	0.328	**1.104**	3.500	**4.604**
02310 10001	NATIONAL POWER TRAINING INSTITUTE	0.855	0.123	**0.977**	3.103	**4.080**
02310 11001	NIGERIA ELECTRICITY LIABILITY MANAGEMENT LIMITED	0.117	0.093	**0.210**	0.236	**0.446**
	TOTAL	**3.127**	**1.136**	**4.262**	**70.000**	**74.262**

Source: Budget Office (See http://www.budgetoffice.gov.ng/2013budget_details/24.%20Summary_Power.pdf)

However, at the end of 2013, most of the monies appropriated to the REA for rural electrification projects was returned to the national treasury, due to lack of implementation of the budget for RE projects under the financial year in line with the FGN's appropriation policy. This led to the temporary suspension of the REA Managing Director.

This does not augur well for the rural electrification ambition of the FGN, as there are numerous projects requiring funds for execution, returning funds meant for rural electrification to the treasury slows down the drive. More so, the FGN as a matter of policy reduces monetary appropriation to its agencies that do not utilize monies hitherto appropriated in the preceding year, therefore, the REA gets less money (8.2 Billion Naira) from the National

[74] As at 19th June, 2014 exchange rate was 155.73 Naira to 1 dollar. See http://www.cenbank.org/rates/ExchRateByCurrency.asp (last visited on 19th of June, 2014)

Assembly for year 2014 based on Nigeria's appropriation act of 2014[75]. This will affect project implementation even further in the year 2014, thus, there is the need for a more committed executive team to carry out the rural electrification ambition of the FGN.

However, the Transmission Company of Nigeria (TCN) which is in charge of extending the 133kVa and 330kVa transmission lines to currently inaccessible areas in the country got a capital budget of 33.8 Billion Naira ($204 Million) in 2013 from table 5.2 above. Summing this up with the REA budget of 26 Billion Naira ($157 Million) in 2013 gives a total sum of 59.8 Billion Naira ($362 Million) for both rural electrification and grid extension.

We observe that the 2013 budget for REA ($157 Million) was within the projected investment requirement ($44-241 Million) under the BAU scenario, and progress can be made if this level of funding is maintained. However, the REA only got a budget of 8.2 Billion Naira ($49 Million) for 2014, which falls short of the projection and represents a drastic reduction of 68.7% budget appropriation for the REA. From the foregoing, it could be concluded that the REA's investment requirement projection from 2007-2020 has already suffered a number of set-backs, which includes:

i. Uncertainty about Estimation Tools: There is a lack of clarity as to how the investment costs were arrived at, and doubtful if it represents the clear picture of the magnitude of the problem of lack of electrification in rural Nigeria. This gap, which is one of the motivations for this research, was addressed in chapter 4, where a more robust analysis was carried out to estimate the cost of investments required, using the Network Planner Model;
ii. Mono-Funding: It is observed that mainly the FGN funds rural electrification in Nigeria. This is further compounded by the inconsistency and dwindling nature of funds being appropriated to the REA by the FGN. Other sources of funding especially international donors have not collaborated with the REA yet due to a lack of official

[75] See http://www.nigeriaintel.com/2014/01/02/power-ministry-budget-still-high-despite-privatisation/ (Last visited on the 27th of March, 2014)

rural electrification master-plan, as well as an implementation strategy;

iii. Lack of Planning: Though investments under the BAU scenario are to be made based on equity and geographical spread. However, some geographical zones especially in the North are far more affected by the problem of lack of electricity compared to the South. A proper plan of how to close the gap and prioritize investments based on need should be paramount;

iv. Governance and business setting: The issue of corruption and government bureaucracy constitutes a huge challenge to rural electrification in Nigeria. The REA was scrapped in 2009 due to allegations of corruption and misappropriation of 5.2 Billion Naira and was only reconstituted in 2012, and its board inaugurated in September, 2013. The NERC also had its board members sacked in 2009 by the late president Umaru Yar'adua due to allegations of fraud, and was reconstituted with a new board in 2010. These periods witnessed a slow-down of the reform process and affected the integrity of these agencies negatively. However, with the inauguration of the new board, no cases of corruption have occurred, and it is hoped that it remains that way going forward.

The REA is also seen by politicians especially members of the national assembly as an avenue for them to execute constituency projects, upon which the smooth passage of REA's annual budget is hinged. In this case, it is either the REA inserts projects in their budget for every parliamentarian's constituency that might not be top priority, or they frustrate the passage of the budget. This poses a huge challenge for planning based on priority areas of rural electrification in Nigeria.

Cases of vandalism and sabotage of electricity infrastructure are also prevalent in the country, which reduces the reliability of supply and increases costs. With the privatization of the generating and distributing assets, it is hoped that adequate security can be provided for these facilities, and the government needs to do more in this regard too.

Therefore, it can be deduced from the above lapses that the ‘business as usual’ scenario even if implemented will not ensure universal access to electricity in Nigeria by 2030. It is also obvious that even the 75% electrification target by 2020 and at least 10% of renewable energy mix by 2025 is not feasible if REA fails to utilise its budgetary allocations year after year.

5.3.2. Funding under the Network Planner (NP) Scenario

In the Network Planner (NP) Scenario, an estimated US$34.5 Billion is required to achieve universal access to electricity between 2013 and 2030 in Nigeria. This is USD$26.7 Billion higher than the ‘Business as Usual’ case. This estimate was arrived at by first determining the optimal combination of grid, mini-grid and off-grid solutions required for extending 100% access to electricity in Nigeria. Extending electricity access to areas currently without access in Nigeria is cheaper through the grid option, and 98% of the extension is grid-compatible, while the remaining 2% is mini-grid compatible.

Table 5.3 below shows a breakdown of required investments for universal electrification in Nigeria, as well as anticipated main and alternative sources of financing. The remaining part of this scenario considers how additional resources can be mobilised for rural electrification for grid, mini-grid and off-grid projects. Alternative models for rural electrification are also considered, as well as how more resources can be mobilized for the REF.

Table 5.3: Investment Requirement for Universal Electrification in the NP Scenario

	Annual Investment ($ billion)	Households gaining access annually (million)	Percentage of Households Electrified	Main Source of Financing	Other Sources of Financing
On-Grid	1.9	1.6	98%	FGN Budget Private sector	Multilateral and bilateral guarantees
Mini-Grid	0.039	0.0379	2%	Private sector	REA support, Multilateral and bilateral concessional loans

Source: Results from analysis in chapter four

This estimate covers the extension of MV transmission lines of 12,193,060m, LV distribution lines of 711,954,700 within the planning period. An estimated 28.5 Million households or an equivalent of 125 Million Nigerians are projected to be provided electricity access by the end of the planning period in 2030. The off-grid technology seems to be unviable given the base scenario parameters and time horizon, but, sensitivity analysis shows that a decrease in the cost of solar panels, and increase in the Mean Inter-household Distance (MID), makes the off-grid technology viable.

5.4 Financing Grid Electrification in Nigeria

In the NP Scenario, grid electrification in Nigeria requires an annual investment of USD$1.9 Billion from 2013 to 2030. This estimate is USD$1.65 billion higher than the projected annual investment for 2007-2040 in the 'Business as Usual' case, and provides electricity access to an additional 1.06 million households per year.

Two main sources of financing are identified for grid expansion in Nigeria: Private Sector and FGN Budget. An additional source of financing is anticipated to come from Multilateral and Bilateral guarantees. Here, the private sector is expected to invest in power generation and distribution, while the FGN would invest in transmission and rural electrification.

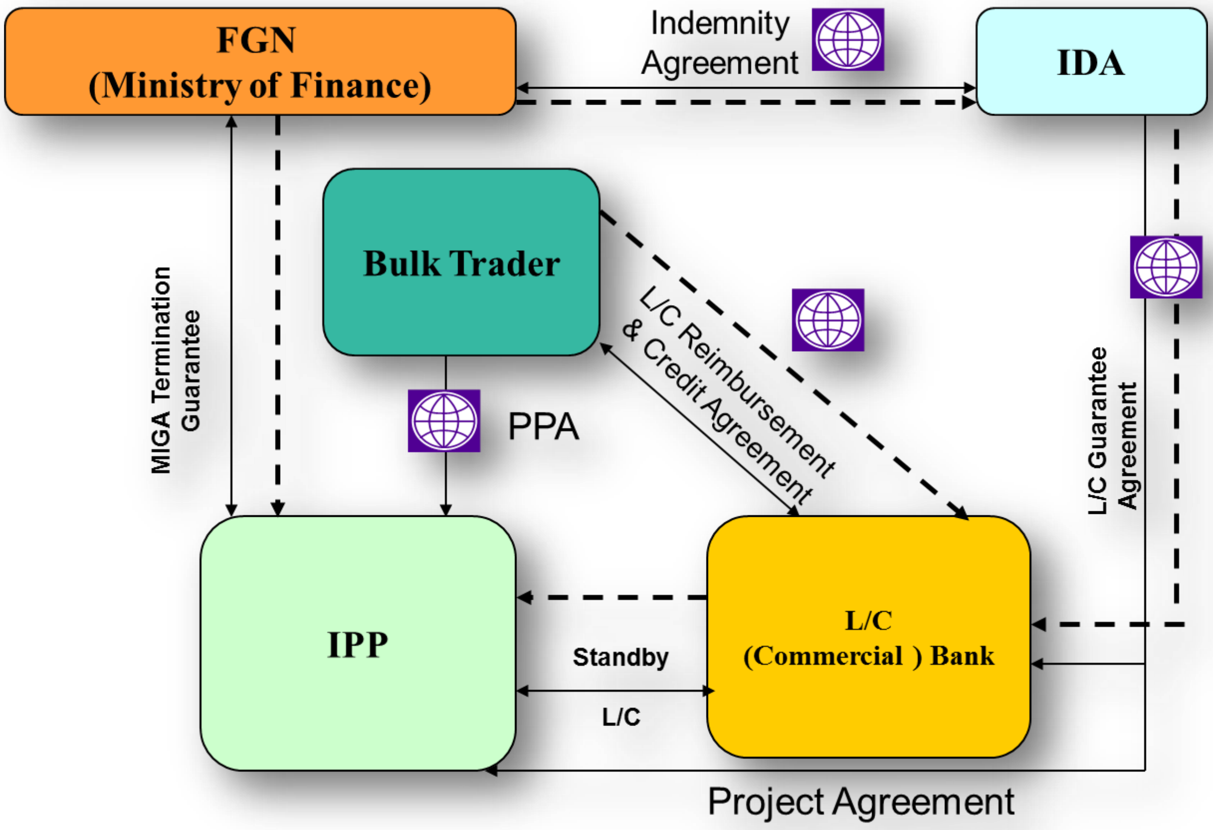
Nigeria's current electricity market reforms are such that power generation and distribution companies hitherto owned by the government have now been privatised, while transmission of electricity is still under the FGN via the Transmission Company of Nigeria (TCN), as well as rural electrification via the REA. Thus, the private investors are expected to be able to source loans and also inject equity into power generation and distribution projects given the incentives currently provided by the FGN for grid electrification.

It is important to point out here that while the privatised distribution companies (disCos) are out for profit, and may not necessarily make profit from expanding to rural areas, it is part of their Corporate Social Responsibility (CSR) obligations to facilitate and promote rural electrification initiatives within the first five years of their license. This is tied to the business plan and performance agreement that formed part of the documents used to bid for the disCos during the privatization process[76]. Thus, this forms part of the terms of reference of the 10 year initial license granted to the disCos.

Some Multilateral and Bilateral agencies such as the World Bank (WB) and African Development Bank (AfDB) currently provide Partial Risk Guarantees (PRG) for some power generation projects in Nigeria. MIGA cover is also provided for a number of IPPs. Figure 5.1 below shows how the World Bank PRG for IPPs works in Nigeria's Electricity Supply Industry.

[76] This can be found in the technical proposal/A-3: Business plan of Integrated Energy Distribution Marketing LTD.-Owners of Yola Electricity Distribution Company. This document was made available to researcher on request by the legal department of the NBET, being an intern there as at April 2014.

Figure 5.1: PRG Revolving Standby L/C Facility and MIGA Termination Guarantees in Support of IPPs[77]



Some of these incentives provided by the FGN under the current reforms include:

a. The establishment of a 'bulk trader' called the Nigerian Bulk Electricity Trading (NBET) PLC in charge of purchasing all the generated electricity capacity from generating companies (GenCos) through a mutually negotiated 20 year Power Purchase Agreement (PPA) with a cost reflective and fair tariff, as well as a Vesting Contract with the distribution Companies (DisCos);
b. Government bears the risk of gas supply if the GenCo gets gas from the Nigerian Gas Company (NGC). This implies that if the GenCo cannot perform or generate electricity as a result of gas supply

[77] This sort of arrangement can also work for rural electrification whereby the REA can leverage on its REF to act as an off-taker of rural electrification projects, and multilateral and bilateral agencies provide PRG and other supports.

constraint from NGC, and not as a result of the GenCo's fault, then the FGN through the NBET would pay the GenCo for the total capacity that it should have generated if it had gas, and the energy it actually generates;

c. Government bears transmission risk if the System Operator (SO) asks the GenCo to step down the amount of power it would have been able to put on the grid, as a way of managing the transmission system. NBET still pays the GenCo for the capacity it was ready to transmit before the SO directive, as well as the energy it actually adds to the grid;
d. The PPA allows for a fixed tariff that is cost reflective, with a reasonable Internal Rate of Return (IRR) at the end of the 20 year period. The tariff takes account of inflation and exchange rate fluctuations by yearly indexation;
e. The FGN also takes Local Political Force Majeure (LPFM) risk, which means any form of local political disruption that affects the ability of the GenCo to perform its obligation would not affect capacity payment from NBET;
f. Zero Percent (0%) duty for equipment and machinery imported into Nigeria for power sector use;
g. 5-7 years tax holiday granted to pioneer companies that manufacture meters, transformers, switchgears, control panels, cables and other electrical related equipment in Nigeria; and
h. Assessment of gas-fired power plants under the company income tax regime that offers a reduced rate of 30%.

The NBET is also well funded to enable it meet its obligations to the market. It gets its funds from different sources which includes; approximately $150 Million DisCo receivables monthly, 3 Months DisCo payment guarantee to mitigate market shortfalls, $350 Million Eurobond funding, USD$325 Million Escrow proceeds from the sale of Egbin plant during privatisation, and yearly capital supplementation from the FGN budget of approximately

USD$145 Million. All these provide some comfort for private investors to invest in grid electrification in Nigeria.

Given the results of the analysis done in chapter four of this study, where 98% of grid extension was recommended for rural electrification in Nigeria, and the fact that the Transmission Company of Nigeria (TCN) is still government owned and controlled, it is expected that additional investments for transmission network expansion would come from the FGN. Further, a concession arrangement could be worked out with a private investor to manage the transmission lines, which could be a Public Private Partnership (PPP) model. Extending this network (330Kv and 132Kv lines) to the rural areas is a necessary first step towards achieving energy for all by 2030.

The REA is expected to partner with distribution companies, state governments, local governments, NGOs, Multilateral and Bilateral agencies on a PPP arrangement to also extend grid access to rural areas. However, a clear policy on rural electrification as well as master-plan and strategies for implementation would have to be in place first to explore these options.

Rich states like Lagos, Rivers, Akwa-Ibom and Delta are expected to go into partnerships with IPPs to generate embedded power of up to 20MW based on the regulations limit for embedded generation in Nigeria. The state guarantees the IPP that whatever they generate, the state will buy, and such projects are usually located close to their target population, and distribution networks are part of the contract. This incentivises private investors to key into the process, and allows for accelerated expansion of electricity access to rural areas. Oando Power Company is an example of a private investor that has taken advantage of the embedded generation/captive power license provision of NERC to provide electricity to some parts of Lagos[78]. Another model that can be adopted is the franchisee model which is described in sub-section 5.7.4 below.

[78] See http://businessdayonline.com/2013/11/oando-ready-to-partner-government-on-power-projects/#.U1j406LDWCA (last visited on 24th of April, 2014)

Therefore, there is a paradigm shift from the business as usual case where the FGN is funding grid electrification 100% prior to the reforms, to the NP scenario where the FGN is anticipated to provide 20%[79] capital subsidies for funding grid electrification projects for rural electrification, while the private sector and Multilateral/Bilateral agencies would account for the remaining 80%. Thus, government as a source of financing rural electrification in Nigeria should be limited to grid expansion and funding interventionist agencies like the rural electrification agency, while also providing the right incentives for private investments to thrive, and partnering with the private sector were necessary to fund rural electrification projects.

5.5 Financing Mini-grid Electrification in Nigeria

In the NP case, mini-grid requires an annual investment of USD$39 Million per year from 2013 to 2030 to achieve universal electricity access in Nigeria. This will provide access to an estimated 37,900 rural households yearly. This is expected to be financed mainly by the private sector/Multilateral and Bilateral agencies (80%)[80] and the FGN providing (20%) capital subsidies for the rural electrification mini-grid project.

The private sector is anticipated to take advantage of the embedded generation provisions of NERC, where up to 20 MW of power can be allowed, or the captive power license, where electricity can be generated for mini-grid electrification. The FGN through the REA would provide the necessary incentives – especially a cost reflective tariff, and prepare a 'bid-ready' project, where the most competitive developer wins. An example of this arrangement is what the World Bank is currently working on with the Nigerian government, to develop a 'bid ready' investment plan to potential private sector investors in renewable energy (solar power) generation in the North. An estimated $250 million dollars Clean Technology Fund (CTF) allocated to Nigeria is to be used for this project.

[79] This is based on the intention of the FGN in terms of the paradigm shift in funding rural electrification going forward. The draft RESIP is still being reviewed as at April 2014, and researcher is privileged to be among the review committee, hence, the access to this information.
[80] *Ibid* note 70

Other arrangements could be spear-headed by state or local governments in collaboration with REA and other interested stakeholders towards preparing a well-designed competitive procurement process especially for renewable technologies for developers to bid. The loans or grants available from multilateral and bilateral sources could be used to support the costs involved in handling this initial process.

Another model which can also be promoted in Nigeria is the investment in captive power projects, where there is a base load that off-takes the power generated, while the excess forms a mini-grid for nearby communities who will pay a certain tariff that would be agreed with REA, NERC and consumers. An example is the United Nations Industrial Development Organization (UNIDO)'s 400kW Small Hydro Power (SHP) installed for Mambilla beverages (Nigeria) Limited in Taraba State[81].

This was a PPP between the Taraba State Government, United Nations High Commission for Refugees, International Centre for Small Hydro Power Plant (ICSHP) and UNIDO. Mambilla beverage Limited which is a productive activity serves as a base-load for the project and consumes about 250kW, while the excess is given to the surrounding rural communities as part of corporate social responsibility. The State and Local government here provided the land and did civil works for the hydro plant site, UNIDO and other sponsors provided the turbines, and the plant will be maintained by the Mambilla beverages Limited.

Another model suggested is a PPP based on the proliferation of telecommunication masts all over rural Nigeria who depend on diesel generators that would cost an average of 55 Naira/kWh. However, a model that uses renewable energy technology such as solar and wind, or a hybrid, can serve the same purpose for the telecommunication mast at a cheaper rate (45 Naira/kWh for solar) as well as serve as a mini-grid for nearby rural communities. The State and Local Governments, as well as REA could be

[81] See http://www.unido.org/news/press/unido-nigeria-4.html (last visited on the 3rd of April, 2014)

stakeholders, while the telecommunication service provider would serve as a base-load.

The NERC has issued a lot of licenses for grid, captive power/mini-grid, embedded and off-grid generation[82], as well as put regulations in place for them; however, just a few of the licensees have actually gone ahead to invest. This is part of the reason why the industry is shifting towards competitive procurement of power, away from unsolicited bids.

5.6 Financing Off-grid Electrification in Nigeria

Although the NP scenario did not recommend the off-grid option as a viable one based on the base case results of the analysis in chapter four, sensitivity analysis shows that if the cost of solar panels reduces to USD$500, it would make off-grid the preferred option for 34% of the unelectrified households at a total annual investment of USD$613 Million.

The REA who currently funds off-grid electrification almost 100% through the REF, is expected to provide an estimated 20%[83] of the required investment for off-grid projects, while private initiatives, cooperatives, community based models, PPP, Fee-for-service models, states and local governments are anticipated to provide the remaining 80% of the requisite investments for off-grid electrification in Nigeria by 2030. The advantages and challenges of some of these models are described in table 5.4 below:

[82] See http://www.nercng.org/index.php/industry-operators/licensing-procedures/licencees?start=20 (last visited on the 24th of April, 2014)
[83] *Ibid* note 70

Table 5.4: Business Models for Off-grid Electrification-Advantages and Challenges

	Small Hydro	Solar Home Systems	Solar Lanterns	Biomass
Average Pricing	$0.042–0.054/kWh	$150-$450/unit	$11-$35/unit	$0.17-$0.28/kWh
Competitive Advantage	Reliable; Low upfront cost; Sized to meet demand	Customized based on individual requirements	Long term Cost savings for rural households using kerosene	Reliable; Low upfront cost; Sized to meet demand
Business Model	Supplied to villages through existing underutilised grid infrastructure; paid at government determined tariffs	Sold on credit, in partnership with local banks. Users typically pay 10%-25% upfront and the rest in instalments	Bulk sales to corporate, NGO, and microfinance institutions (MFIs) partners; sold directly to consumers through local retailers	Provided through company-owned mini-grids; priced to existing expenditure levels
Challenges	highly dependent on regulation tariffs set by government; requires negotiation of power purchase agreement (PPA	Pricing currently too expensive for the rural poor; adequate maintenance is difficult in remote rural areas	Government subsidies for kerosene use dissuade consumers; charitable distribution schemes distort the local market	Correctly estimating demand to optimise plant size and load
Opportunities	Government subsidies can reduce expenditures; carbon credits can generate new	Leasing options for solar home systems may be tried out, as in Brazil and USA	Industry group push companies' interest, provide resources to reduce misuse and implement	Government subsidies can reduce expenditures; carbon credits can generate new revenue sources;

	revenue sources; PPAs in grid-connected regions can minimise demand risk by allowing companies sell power to government		pay-per-use business models that mirror purchasing patterns and income streams	PPAs in grid-connected regions can minimise demand risk by allowing companies sell power to government

Source: Bank of Industry (Nigeria)

In conclusion, mobilising financial resources to provide universal electrification in Nigeria by 2030 under both scenarios remains a major challenge. Yearly budgetary allocations to the REA alone are not sufficient for rural electrification in Nigeria. Therefore, there is the need to create the enabling environment to attract Public Private Partnership (PPP) initiatives, and the private sector towards investing in rural electrification in Nigeria.

As observed from the interviews conducted with stakeholders in Nigeria, there are limited efforts in terms of rural electrification in Nigeria at the moment. Thus, not much has been done to spur private investments or PPP in this regard. The lack of political will and commitment, as well as the lack of an official REM and RESIP has been identified as the missing link needed to kick-start the process.

Additional sources of funding that could be considered to augment the Rural Electrification Fund (REF) towards financing rural electrification programmes are;

i. **Renewable Energy Development Charge (REDC):** The REDC law should be enacted in Nigeria. This charge would be obtained by charging a small amount of say 10kobo per kWh to the electricity market, to be borne by the electricity consumers. Preliminary calculations based of the Multi Year Tariff Order (MYTO) II electricity generation projections show that an estimated 2.8 billion naira is realisable in 2013. As electricity generation and distribution improves, it is also estimated that by 2030, 8.7 billion naira can accrue from the

REDC. However, this source of fund would only be used for qualifying renewable energy projects below 10MW, which automatically makes application of the funds majorly for rural off-grid and mini-grid renewable projects;

ii. **Rural Electrification Fund (REF) Tax:** The REF law can be amended to expand its sources of income to provide for a percentage of tax from all registered companies in Nigeria as well as oil and gas companies. The Federal Inland Revenue Service (FIRS) would be in charge of collecting the tax from all registered companies in Nigeria and remitting to the REF. This kind of arrangement is already in place in Nigeria with the Petroleum Technology Development Fund (PTDF) and the Tertiary Education Trust Fund (TETFund). Thus, it could be extended to the REF if the government is committed to rural electrification in Nigeria;

iii. **Corporate Social Responsibility (CSR):** Rural Electrification promotion and facilitation should be made an obligatory CSR for oil companies and all stakeholders within the Nigerian Electricity Supply Industry (NESI). The FGN needs to create awareness in this regard and make all stakeholders in the oil and gas sector and electricity sector commit to making rural electrification one of their CSRs. This will help in raising additional funds towards rural electrification in Nigeria;

iv. **Crowd funding:** The REF could also benefit from potential crowd funds. This is a project that can be initiated as non-profit towards helping the cause of rural electrification in the country by pooling together a collection of finance from various sources. The funds collected will be used for rural electrification projects only, and could also help in additional funding for the sector.

v. **Private Equity Funds (PEF):** Opportunities for creating a renewable energy private equity fund should be explored in Nigeria. This model presents an alternative option that has worked for long term investors that have long term liabilities such as insurance, sovereign wealth fund, pension and endowments in other countries. The PEF have also been found to nurture innovations and can finance new industries such as the renewable energy market in Nigeria.

The use and promotion of PEF to unlock and channel sources of long term capital towards renewable energy projects in Nigeria, will not only act as a credible alternative source of funding for the industry, but also indirectly aid rural electrification through the sort of projects that will be developed from the Fund.

5.7 Business Models for Rural Electrification

5.7.1 Public-Private Partnerships (PPP) and Commercial Models

Based on the experience of China, the Nigerian government can embark on PPP arrangements towards funding rural electrification projects in Nigeria. By taking part ownership of a project or buying into a commercial model, government provides security and incentives for private individuals to come into the rural electrification business. An example of such arrangement is in the oil and gas sector of Nigeria, where government goes into joint ventures with international oil companies (IOCs), with a revenue sharing formula. The Mambilla plateau 3,050MW hydroelectric project being embarked upon in Taraba state by the FGN is going to be a PPP, so also is the 30MW coal to power project in Bauchi state, and the pilot 10MW wind power in Katsina state[84].

More of these collaborations between the government and private individuals have to be put in place especially in transmission and distribution. The FGN and REA can work out a model with the discos whereby, they both invest in expanding the distribution network to rural areas and hand over its operation to the discos, which in turn pay the government back for this investment over a number of years. The proceeds realised by government from the privatisation of the Gencos and Discos could be channelled for this purpose, as well as budgetary allocations to the REA.

[84] See http://allafrica.com/stories/201208240480.html (last visited on the 17th of December, 2013)

Nigeria can also leverage on partnership opportunities provided by the Barack Obama government-led Power-Africa initiative announced in June 2013 by President Barack Obama of the United States of America, on his visit to South Africa. Nigeria is among the six focus countries of the initiative, other countries are Ghana, Ethiopia, Tanzania, Liberia and Kenya. The objective of the initiative is to add 10,000MW of clean electricity generation by expanding mini-grid, off-grid and transmission infrastructure of the aforementioned countries. An initial $7billion in financial support and loan guarantees have been made available for this initiative, and a further $14billion have been committed by PowerAfrica's financial partners in the form project finance, via direct loans, equity investments and guarantee facilities[85].

The viability gap funding model which was suggested in chapter three can be replicated in the country as funding financing option for rural electrification in the country. Here, interested electricity companies bid for their respective required value of subsidies based on a prearranged rate for a number of electricity connections. As a standard, electricity providers are allowed to choose the technology options and solutions that are cost-effective under such auctions, and they are not tied down to particular technology types.

5.7.2 Co-operatives

According to Tchami (2007), a cooperative is a business organisation owned and operated by and for the overall benefit of its members. In a similar vein, an electric cooperative works for the benefit of its members and are usually businesses governed by democratic tenets and driven by societal goals of local development (Bhattacharyya, 2011). The USA, Nepal, India, Bangladesh and Philippines are among countries that have experimented with this model.

The promotion of equal participation, one member one vote system and empowering rural dwellers towards local participation are some of the

[85] See http://www.usaid.gov/powerafrica/about-power-africa (last visited on 1st of January, 2014)

advantages of the cooperative model (Cruickshank and Yadoo, 2010). The underlying principles for this model are; communal interests; voluntary and open membership; economic cooperation of members; training, information and education; cooperation among cooperatives; independence and autonomy; and democratic control of members.

Just as the Rural Electrification Board (REB) of Bangladesh used an electric cooperative called Palli Bidyut Samities (PBS) to extend electricity access to rural areas in Bangladesh, Nigeria's REA can borrow a leaf from this and collaborate with the discos to use electric cooperatives for an accelerated rural electrification experience in Nigeria. This gives a sense of ownership and participation to the rural dwellers who are also members of the cooperative society.

Another advantage of this system is that it allows members to plan for the electrification of its coverage area based on projections of load growth. Members here are also customers, and are in charge of managing the operational and financial responsibilities of the cooperative based on some set rules and regulations. With the support of the REA in terms of training and capacity building, the cooperative designs and plans the network, as well as construction and other related supports.

There are also stringent measures for checks and balances among members in all processes to prevent corruption in the REBs. The REA would also be thorough in its oversight functions on the cooperatives. Efficiency in operation and improvement in distribution losses are also some of the benefits of operating this system based on the experience of Bangladesh. Nigeria does not currently have this arrangement in place; therefore, it is imperative to look at the potential of tapping into the benefits provided by this model towards expanding electricity access to rural electrification in Nigeria.

5.7.3 Fee-for-service models/ESCO

For isolated rural communities in Nigeria, off-grid/stand-alone systems such as Solar Home Systems (SHS), solar water heaters, hybrid systems etc. will go a long way is providing modern energy access to such areas. The Energy Service Company (ESCO) is a company that provides these services. They provide energy services to customers, as well as own, install and operate energy systems in rural areas. They are also responsible for maintenance and repairs of the system and provide replacement parts where needed throughout the life cycle of the project. It is a wholly private arrangement, and they make their money by charging consumers a fixed amount monthly or rent out the equipment for a fee, hence, the fee-for-service model.

This model has proved to be successful in some developing countries, and best practice countries of this model include India and Zambia. With the right framework and policies, this model can also be adopted in some parts of Nigeria. Among some of the advantages of this model are: very good customer service; ideal for low income rural areas as only a token monthly fees are required to be paid as opposed to buying the equipment upfront; and the company can obtain good financing terms from donor agencies which could translate to lower fees for consumers.

5.7.4 Franchises for Electricity distribution

India is a success story for this model towards rural electrification. Under this arrangement, there is a PPP between the disco and the franchisee, who is empowered to either build/operate a generation and distribution entity or distribute electricity within an area for an agreed duration, and pull together revenues straight from the rural customers.

The franchisee may have the choice of off-taking supplies from power utilities, generating electricity based on its requirement, or both. Amongst the benefits of this model based on lessons from India include; better billing, metering, higher tariff collections, reduced distribution losses and improved efficiency.

The franchise model works in two ways; revenue franchising and input based franchising (Bhattacharyya, 2011). The revenue franchisee is limited to revenue collection, addressing customer complaints, billing etc. but not a partner in loss reduction. The revenue franchisee receives a percentage of collections, incentives for surpassing charges and penalties for not meeting up. The input-based franchisee buys electrical power from the utility and pays the energy charges to the utility at a fixed rate. He makes money by increasing the energy charge rate, and selling to the consumers. The input-based franchisee is also takes care of operations and maintenance of distribution LV lines and transformers.

Nigeria can adopt this model with slight modifications to suit its peculiarities from India's case. Although, the privatised discos were only just physically handed over to their private owners in November, 2013, the franchise model should be one to be seriously considered going forward in the NESI, as the whole industry depends on the revenue derived from the customers through the discos. Therefore, increased revenue collection based on this model will lead to more investments in electricity expansions and transformers, and better efficiency.

Table 5.5 below describes the strengths and weaknesses of some business models used for rural electrification across the globe:

Table 5.5: Comparison of strengths and weaknesses of business Models for Rural Electrification

Business Model	Description	Strength	Weaknesses
Public Utilities	A public utility installs, operates, and maintains the generation and distribution system and collects the tariffs	Experienced Actor - Easier access to financial and technical resources - Potential to achieve economies of scale	Political influence - Often inefficient - Lack of interest and commitment at the local level
Private Ownership	A private company owns and operates the generation and distribution system, and collects the tariffs	Private company may have a certain investment capacity and technical expertise - Driven by efficiency and performance	Concerns only projects which are financially viable or almost financially viable - Implies access to finance - Company needs high technical and managerial competences
NGOs	An NGO installs and operates the generation and distribution system through donor funding	Can work in areas where it is non-profitable to invest in rural electrification	Sustainability can be a challenge
Community Cooperatives	The community organizes itself and sets up a cooperative that own and operate the generation and distribution system	Positive impact on the community in terms of self governance and local interest in the electrification system - Strong interest in the long term maintenance of the system	Long preparation time and need for technical and social capacity building - Risk of technical and financial failure over time - Subject to pressure from community / specific community members
Mixed	Mix of previous models - Ownership and operation can be differentiated and different actors can generate and distribute the electricity - All previous stakeholders can be involved	Combination of the advantages of the different systems	Complexity of agreements - Need for stable partners
Concession	The project or demarcated area is concessioned through competitive bidding for a period of time (e.g. 15 -20yrs)	Strong interest in the long term maintenance of the system and improvement - Driven by efficiency and performance	Company needs high technical and managerial competences - Need for stable partners
Management Contract	The private sector is contracted to operate and manage the project over a period of time	Could be inefficient and give value for money	Company needs high technical and managerial Competences - Driven by desire to make profit

Source: Rural Electrification Agency (Nigeria)

5.8 Barriers and Challenges to rural electrification in Nigeria

1. **Policy Harmonization:** With the EPSRA 2005 setting the stage for reforms in the electricity sector, a lot of agencies and policies were implemented. We have the NERC to regulate the electricity industry, the NBET as the bulk trader to buy electrical power from Gencos and

sell to distribution company (disCos), Operator of the Nigerian Electricity Market (ONEM) or Market Operator (MO) who implements the market rules, System Operator (SO) and Transmission Service Provider (TSP) who dispatch and manage the grid, Discos and Gencos; and they are all bound by the market rules, PPA and Vesting contracts. However, the REA seems to be isolated and operates outside this cycle of the NESI, which makes it look like an academic exercise or an agency created for political patronage. A lot of lip-service has been paid to the issue of rural electrification in Nigeria without much to show for it, unless and until the REA is harmonised properly into the Nigerian Electricity Supply Industry (NESI), it will continue to operate in oblivion and not much will be done in terms of rural electrification.

2. **Political Will:** Lessons from China and other countries of best practice show that with political will and resolve on the part of government, a lot can be achieved. The Nigerian government have not demonstrated the political will to solve the challenge of lack of energy access to the rural areas of Nigeria over the years. Although the REA has been established by the EPSRA of 2005, its impact has not been felt much. In fact, most people are not aware of its existence and what they do. Therefore, a strong political will backed by action is needed to bring about the desired effect of the rural electrification programme of Nigeria.
3. **Funding:** The bane of rural electrification in Nigeria is financing, which is what this chapter addressed. Financing of rural electrification needs to be galvanised from all possible sources as provided by the financing options suggested herein. This needs to be given priority to fast-track the rural electrification drive of the country.

4. **Inadequate Income Generating Opportunities**: There is need to create opportunities for economic and high income generating activities for the rural dwellers in Nigeria. The lack of this opportunity

discourages private investment flows to the rural areas, as they would not have the means to pay for the energy services rendered by the private sector.

Therefore, at local, state and national levels, deliberate policies targeted at stimulating the rural economy towards employment activities and income generation should be promoted.

5. **Poorly directed subsidies:** The government provides yearly subsidies for low electricity consumers connected to the grid (R1 and R2 consumers). Though this is a good idea on paper, the implementation does not get to the targeted low income bracket. This is because the definition of an R2 consumer is so broad and imprecise that majority of those that enjoy this subsidy are the rich people of the cities. The fact that most rural communities that actually need the subsidy are not connected to the grid also poses a challenge for rural electrification in Nigeria. Subsidies need to be targeted at those that need it the most, especially the rural people of Nigeria.

6. **Inadequate Capacity:** Rural electrification projects are usually awarded as contracts to contractors. However, most capital intensive components (transformers, cables, insulators etc.) used for rural electrification projects in Nigeria are imported. Although, several others such as concrete poles, stay blocks, wooden cross-arms etc. are produced locally, there is need for capacity building and promotion of investments in the manufacturing of these capital intensive components locally.

7. **Lack of Planning:** It was observed from the few countries examined in chapter three of this thesis that their rural electrification programmes were carried out in planned phases. The REA of Nigeria currently does not have any comprehensive plan, data or survey of areas that do not have access to electricity in the country. Contracts are awarded based on political patronage and influence from politicians in the parliament

for projects to be sited in their constituencies irrespective of need and priority.

This affects proper planning for prioritization of projects based on needs, and makes a mockery of the overall rural electrification objectives of the government of Nigeria.

5.9 Transition period (2013-2030)

Given the NP modelling results from chapter four, which recommended 98% grid extension and 2% mini-grid for households currently without access to electricity in Nigeria, it is important to have a transition plan. Therefore, the distribution companies (disCos) should provide a business plan for expansion over the next five years to the NERC, which allows the REA to know areas that would be without access in five years. This will enable the REA to embark on off-grid rural electrification projects in such areas as a stop-gap measure pending when grid expansion is feasible.

Further, to ameliorate the cost of waiting for electricity on households currently without access in Nigeria till 2030, it is imperative for the REA to have a phased rolling plan (3, 4 or 5 years), with prioritization based on current levels of penetration of electricity supply in various states. For example, states that have less than 50% electricity supply penetration should be prioritized over those that have 70% penetration and above etc. More off-grid and renewable solutions could be deployed to the Northern states of Nigeria since they are worse affected and have huge potentials in terms of renewable energy sources such as solar, wind, biomass and hydro.

5.10 Summary

This chapter provided various options for financing Nigeria's rural electrification programme based on estimates derived from the spatial electricity planning model analysis carried out in chapter four, which recommended 98% grid expansion for the purpose of rural electrification as the least cost technology option, and 2% mini/off-grid technology option.

Interviews conducted to get feedbacks from stakeholders within and outside Nigeria also provided an understanding of the current state and direction of the industry as well as a basis for proffering financing options for this research.

A scenario analysis was carried out to describe the business as usual case towards determining the pathway for rural electrification based on current funding efforts of the government, and an NP scenario to provide alternative funding pathways based on the results in chapter four.

Some barriers to rural electrification in Nigeria were also identified in this chapter, and it is suggested that a combination of some or all of the financing options discussed herein be adopted in tackling the rural electrification challenge of Nigeria.

It is also clear from this chapter that the government has to take the lead in developing a financing framework, providing more funds for extending the transmission lines, partnering with the distribution companies towards expanding the distribution lines to rural areas, and above all, having the political will to carry out the rural electrification objectives of the country.

Lastly, a blend of some or all the financing options recommended in this chapter is required, as this will ensure more sustainability and effectiveness towards rural electrification in Nigeria.

CHAPTER SIX
CONCLUSION

6.1 Introduction

This chapter concludes the thesis by reflecting on its significant findings, recommendations and potentials for further research. The research carried out here examined financing options for providing electricity access to the rural areas of Nigeria that currently do not have access. In doing this, it answered three key questions:

- What combination of Grid, Mini-grid and Off-grid electricity supply options should Nigeria adopt in providing universal electricity access to her diverse rural areas by 2030?
- What is the investment requirement towards achieving universal electrification in Nigeria by 2030?
- How can this investment be financed?

In addressing these questions, the research adopted a triangulation analytical framework that was both qualitative and quantitative. An extensive review of literature was carried out in the following areas: financing rural energy projects, financing sources and mechanisms; and methodologies for analysing rural electricity supply. Further, reviews on the UNDP Report on country experiences on financing options for renewable energy (2008); Electricity supply and demand status in Nigeria; and Nigeria's rural electrification experience were also provided.

Other reviews carried out include: financing rural electrification in Nigeria; technology choices for rural electrification in Nigeria; overview of Nigeria's draft Rural Electrification Policy; organisational arrangements for governance of rural electrification in Nigeria; and constraints to expanding rural access to electricity.

With the aid of the '*Network Planner model*', a spatial electricity planning analysis was carried out using relevant Nigerian data (demographic, economic, electricity etc.). This was used to answer the first and second questions of this thesis. Here, a nation-wide analysis was carried out to include the 36 states of Nigeria and the Federal Capital Territory Abuja, using data from the 774 Local Government Areas of Nigeria.

The Network Planner was chosen for this research because of its usefulness in rapidly estimating connection costs and comparing different electricity supply options towards determining the least cost option (grid, mini-grid or off-grid) for different communities in Nigeria.

The analysis, which was carried out over a one month period (June-July 2013) at the Energy Centre in Kumasi-Ghana, provided cost estimates for extending 100% electricity access to over 125million rural dwellers of Nigeria that won't have access to electricity in Nigeria at the end of the 17 year planning period (2013-2030). The total estimate is put at US$34.5 billion, with 98% of the households recommended as the least cost for grid extension, while 2% of households are compatible for diesel based mini-grid systems.

6.2 Research Findings

The first objective of this study as outlined from the outset was to carefully analyse appropriate electricity supply modes (grid, mini-grid and off-grid) that Nigeria can adopt to provide universal electricity access to her diverse rural population in 2030. This objective was fundamentally addressed in the data analysis chapter, 4, with the aid of the '*Network Planner model*', where the grid extension was recommended as the least-cost technology option for rural electrification in Nigeria for 98% of the households currently without access to electricity in the West African Country. While the remaining 2% of the households currently without access to electricity in Nigeria was recommended for a diesel-run mini-grid system.

The second objective, which was to estimate the investment requirement towards achieving universal electricity access to all Nigerians in 2030, was also addressed in chapter 4 of the thesis. The cost estimate derived from the analysis is US$34.5 billion, being the cost of providing electricity access to 125million Nigerians or 28.5 million rural households at the national level. A further cost analysis at a disaggregated level was carried out to have an idea how much it will cost each of the 36 states in Nigeria and the Abuja to extend electricity access to their rural areas. The cost breakdown by states is shown in table 6.1 below, and a further breakdown is shown in appendix 2.

Table 6.1: Rural Electrification Cost Breakdown by States in Nigeria

State	Total Costs (billion US$)	State	Total Costs (billion US$)	State	Total Costs (billion US$)
Abia	0.446	Enugu	0. 867	Niger	1.303
Adamawa	1.368	FCT-Abuja	0.355	Ogun	0.535
Akwa-Ibom	1.047	Gombe	0.768	Ondo	0.902
Anambra	0.304	Imo	0.199	Osun	0.465
Bauchi	1.267	Jigawa	1.336	Oyo	0.912
Bayelsa	0.361	Kaduna	1.598	Plateau	1.104
Benue	1.511	Kano	2.147	Rivers	0.890
Borno	2.287	Katsina	2.009	Sokoto	1.290
Cross river	0.765	Kebbi	0.897	Taraba	1.224
Delta	1.245	Kogi	0.868	Yobe	0. 837
Ebonyi	0.757	Kwara	0.339	Zamfara	1.235
Edo	0.105	Lagos	0.341		
Ekiti	0.351	Nasarawa	0.551		

Sensitivity analysis carried out shows that when solar panels costs reduces to USD$500, 34% of households become off-grid compatible, since it becomes affordable for more households compared to the base scenario. In a similar vein, a reduction in pump price of diesel to USD$0.65 makes 49% of households in Nigeria mini-grid compatible.

Increasing household demand to 400kWh makes 99% of households in Nigeria grid compatible, and reducing it to 250kWh, makes less households grid compatible. It was also shown that increasing the Mean Inter Household Distance (MID) ten households to shift more communities to be off-grid compatible, since the households become sparse and farther from each other, making off-grid stand-alone solutions more cost effective. This had the most impact compared to the base scenario, as increasing the MID to 200 metres makes 56% off-grid compatible and 44% grid compatible.

The third research objective was to determine how to fund the required investment towards achieving the 2030 'electricity for all' objective. This was provided in chapter five of this thesis, where, drawing from the experiences of other countries, the spatial electricity planning analysis carried out in chapter four, on-going electricity reforms in Nigeria, logical assumptions, and a scenario analysis, various financing options were advocated for funding Nigeria's rural electrification programme between 2013 and 2030.

To complement the Rural Electrification Fund (REF) of the FGN, which gets funding from yearly budgetary allocations from the FGN, fines obtained by NERC, surplus appropriation, interests accruing to the Fund and donations from various sources, this study recommends the following additional financing options for rural electrification in Nigeria:

a) The establishment of a Renewable Energy Development Charge (REDC) of 0.10 Naira per kWh charged to electricity consumers in Nigeria, and used for rural renewable energy mini/off-grid projects not exceeding 10MW;
b) The establishment of a Rural Electrification Fund Tax (REFT) Law where a small percentage tax is charged all registered companies in Nigeria for the purpose of rural electrification;
c) Creating awareness and making it obligatory for oil companies in Nigeria to adopt rural electrification as part of their Corporate Social Responsibilities (CSR);
d) Exploring the option of Crowd-funding; and
e) Establishing a Renewable Energy Private Equity Fund in Nigeria.

Further, business models such as PPP, Franchisee model, Fee-for-service Model, Cooperative model, and how they can work in Nigeria was highlighted in this thesis. The need for an enabling environment for private investors to thrive in rural electrification business was also espoused.

6.3 Contribution of Research to Knowledge

This is the first detailed spatial electricity planning and costs analysis ever done using the 'Network Planner Model' as far as Nigeria is concerned. Therefore, analysis of results from this study provided in chapter four, as well as further recommendations (financing options and policy recommendations) enriches the body of knowledge in terms of rural electrification financing especially in Nigeria, and provides a reference point for other researchers, policy makers, planners and other interested stakeholders.

Specifically, findings from this thesis provide insights into the following:

a) The spatial network planning can suggests how to proceed with rural electrification in Nigeria - to extend the grid or rely on local systems. Despite the model limitation, an attempt is made here to identify such choices at the Local Government level, which in itself is a very detailed work.

b) The study also shows that the business as usual scenario will not achieve the universal electrification targets by 2030 and further intensification of efforts will be required. This will be driven by the will and commitment of the FGN via the Ministry of Power and REA, who will coordinate and harmonize activities of all other stakeholders at various levels.

c) Government funding at the current level alone will not be adequate to meet the investment needs for rural electrification. Private investment will have to be encouraged.

d) Enabling environment for private investment has to be created. This can include: creating clear guidelines for the operation of the REF which include but not limited to: transparency in bidding process and criteria for selection of applications; capital subsidies and proper accountability of the REF for rural electrification projects; providing incentives for investors to be provided in the RESIP; and adopting/approving the RESIP without further delays.

e) Any serious planning work requires better data, which is not available at present. Greater attention is required to collect and generate relevant information at the ward/ village levels in Nigeria.

In terms of practical and substantive contributions to knowledge, the researcher as at April 2014 was nominated to represent NBET as a member of the ministerial committee saddled with the responsibility of reviewing the draft Rural Electrification Strategy and Implementation Plan (RESIP) of Nigeria. The draft RESIP is being reviewed to accommodate Mr President's comments and feedbacks. Going forward, the RESIP, when approved will determine the direction of rural electrification in the country in terms of funding, strategy, processes etc.

The knowledge gained by the researcher in the course of this PhD research has been very helpful in contributing to the review of the draft RESIP, which also provides the researcher a first-hand experience of rural electrification policy making at the highest level in Nigeria. The practical experience also gained as an intern at the NBET with access to major stakeholders within the electricity industry of Nigeria, also enriches the quality and contents of this research.

6.4 Recommendations for Further Studies

The research analysis used available secondary data at national, state and Local Government levels. Further studies could be conducted at a more disaggregated ward/village level and if possible with primary data. This will be interesting, especially in finding out how it affects share of each electrification mode (grid, off-grid and mini-grid) recommended and overall cost estimates.

Although, the NP model is currently limited to three technologies (grid, off-grid solar PV and Mini-grid diesel generator), which was what was employed for the analysis of this research. Further studies could incorporate more technologies such as hydro, biomass etc., to have more cost options and estimates available to choose from when planning.

Further studies could also include the technical and geographical constraints of connecting communities, such as hilly terrains, flat-lands, major roads etc., as well as generation costs. The implication of this on overall total capital cost would be an important finding.

The institutional capacity to manage the reform process for rural electrification in Nigeria needs to the strengthened. Although the EPSRA 2005 provides the legal and constitutional frameworks for the establishment of REA in Nigeria, the REA cannot be said to be independent and free from constant interferences from politicians. The organisation and management of REA have also not lived up to the expectations of Nigerians in terms of performance and implementation of rural electrification projects. This is attributable to the lack of the right leadership and appropriate staffing for the agency, as it currently operates without a proper structure.

Therefore, there is need for a restructuring of the REA, as well as recruitment of skilled and knowledgeable staff members in terms of rural electrification, to strengthen the capacity of REA. Proper remuneration is also vital to spur performance, attract the right staff and reduce incidences of corruption.

With a strong, well-structured REA, more efficient NERC, committed Ministry of Power and a president that has the political will to drive the reform process through, REA will be able to mobilise the requisite funds based on the results of this research, as well as effectively implement the rural electrification programme of the country.

6.5 Policy Implications

Having established the importance of modern energy services in the socio-economic and welfare development of rural Nigeria, and gone further to provide cost estimates for expanding access to these areas, as well as options for funding the rural electrification programme of Nigeria, this study holds lessons and implications for various stakeholders in Nigeria. The following are some of the proposed actions for policy makers, REA and the FGN, based on the findings of the thesis:

6.5.1 Implications for policy makers

Off-grid renewable energy technologies such as solar PV was not recommended based on the analysis carried out in chapter four. This is because it is non-viable, as its generation cost is high compared to its return on investment through a prevailing low and subsidized tariff in Nigeria. There is need for policymakers in the country to develop innovative ways of incentivising investments in rural renewable electricity generation projects through appropriate feed-in tariffs or properly packaged 'bid ready' renewable projects such as the one proposed in chapter five of the study. There is also need for policymakers to incorporate the REA fully into the overall energy reforms currently going on in Nigeria.

6.5.2 Implications for Rural Electrification Agency (REA)

In the course of this research, attempts to get relevant data from the REA in Nigeria were futile, as they simply did not have any useful data. Although, the REA's board was only reconstituted in September 2013, after the agency was scrapped in 2009 due to corruption, it is yet to formulate any rural electrification master-plan, or strategic programme of action with target timelines. The REA has had a draft RESIP since 2012 but has not made it official yet, which is slowing down the drive. On the other hand, contracts for rural electrification projects running into billions of Naira are awarded annually even without an official plan and rural electrification programme. In view of the aforementioned issues, which are likely to stall the progress, aims and objectives of the FGN in extending electricity access to rural Nigeria, there is need for the REA to address these anomalies by following the recommendations below:

1. The REA can draw up a long-term rural electrification master-plan based on the analysis of results and cost estimates derived from the spatial analysis carried out in chapter four, the recommendations for

financing rural electrification presented in chapter five, and the experiences of other countries with lessons learnt, which are all important aspects of this research.

2. There is need for the REA to embark on studies and surveys, towards generating a database to get a real picture of the size and nature of Nigeria's peculiar energy access issues, as a yardstick for measuring progress and improvements made by the REA as it carries out its mandate of rural electrification in Nigeria. These surveys could be conducted in conjunction with agencies such as the National Population Commission (NPC) of Nigeria, Nigerian Bureau of Statistics (NBS) and the Independent National Electoral Commission (INEC), to generate a database of household, villages, wards, LGAs, states and national electrification needs. This will help provide valuable statistics for accurate forecasts about how to attain certain time-bound access rate based on the plan of the REA. It will also help other researchers carry out useful research on the subject-matter.

3. The REA's electrification programme should properly integrate Solar PV and other renewable energy systems into the electrification agenda at local and national levels. The use of the Network Planner model could be promoted using primary data at village, local and national levels, to determine more areas suitable for off-grid solutions, as well as mini-grid and grid compatible areas.

4. One way to ensure efficiency and effectiveness of any rural electrification programme is to prioritize according to the level of electricity access in various states. While states like Lagos and Edo in the South of Nigeria have high electrification rates with over 90% and 85% respectively, states like Taraba and Yobe in the North-Eastern part of Nigeria have less than 15% and 25% electricity penetration rate respectively. A logical rural electrification programme will make states of low electricity supply access such as Taraba and Yobe

priority. A phased-rolling approach should also be adopted in the drive to electrify Nigeria. Experiences of most successful countries in terms of rural electrification show that the phased-rolling plan to rural electrification has proved effective.

5. The REA should learn from its recent experience by shunning acts of corruption and judiciously utilizing funds allocated for rural electrification for the purpose it is meant for. There should also be transparency and accountability in the use of these funds in order not to lose public support, which could affect the progress of rural electrification in Nigeria.

6.5.3 Implications for the Federal Government of Nigeria

The FGN needs to take the lead in the rural electrification drive of the nation. There should be an appropriate mix of political will and government resolve, financing, subsidies, improved rural economy and incentives for private investors, for Nigeria to succeed in her rural electrification programme. The need to improve transmission and distribution by reducing losses is also very important; as this will lead to more generation available to areas of need, and the FGN needs to promote this initiative.

Addressing gas supply constraints and transmission constraints is critical towards ensuring an improved rural electrification experience in Nigeria. This is because, as more investments are made in the area of electricity generation by the private investors, especially gas fired plants, the gas feedstock needs to be available to enable the plant operate optimally. The lack of adequate gas has been a major barrier to increasing the generating capacity in Nigeria, and the FGN needs to address this issue frontally.

An important first step in solving the gas supply issue is passing the Petroleum Industry Bill (PIB) currently at the National Assembly, without further delay. Gas investments have halted because of the uncertainty of the PIB; the investors need to be sure of the regulations and incentives offered by the PIB before they make further investments. Therefore, the FGN needs to push the bill through the National Assembly and have it passed urgently, to enable investment flows into the sector.

In mobilizing finance from various sources to fund Nigeria's rural electrification, the FGN needs to pay more attention to expansion of the grid system (transmission and distribution). All funding sources reviewed in chapter three and five needs to be tapped into in order to finance Nigeria's rural electrification programme. More budgetary allocation should also be provided to the TCN and REA for grid expansion to rural areas, by the FGN.

The FGN should facilitate the creation of a task force on Energy Access Data (EAD), which will be responsible for collecting energy related data by conducting energy surveys and censuses required for monitoring the progress of REA in implementing its programmes; analysing energy access data towards providing timely information for the FGN and other interested stakeholders on projections for attaining Nigeria's rural electrification targets.

The Energy Access Database will consist of government agencies such as; Ministry of Power, Rural Electrification Agency, Nigerian Electricity Regulatory Commission, Nigerian National Petroleum Corporation, Energy Commission of Nigeria, Nigerian Bureau of Statistics, National Population Commission, Transmission Company of Nigeria and other relevant agencies.

Furthermore, there is need to harmonize the REA into the Nigerian electricity reform process, and given the requisite attention. Although the EPSRA 2005 makes provision for a REA to be established, however, the on-going power sector reforms operates to a large extent in isolation of the REA. The Nigerian Electricity Supply Industry is fundamentally driven by activities of NERC, TCN (SO, MO and TSP), NBET, DisCos and GenCos, with no major place and incorporation of the REA. This makes the REA operate in isolation; therefore, the FGN needs to integrate the REA into the on-going reforms to give it more impetus.

There should also be decentralization of the energy sector to allow states, LGAs and rural communities harness local energy resources for local consumption and linkage to national grid, which will accelerate access to electricity and investments in rural energy projects. This is especially so, because the local participation in energy developments as learnt from the Chinese experience gave a sense of ownership to the rural communities, allowed various communities to develop at their own pace based on their merits, promoted local technologies and promoted economic activities especially in agricultural productions. All these factors and linkages contributed to the success and sustainability of investments in rural energy projects and the overall electrification drive of some countries of best practices. Thus, Nigeria can take a cue from this decentralization approach to allow for wider access in the rural electrification objective of the country.

However, it is also worthy to note that Nigeria's rural electrification programmes would not be successful without improvements in the economic lives of the rural communities. Agricultural development and small scale businesses can go a long way in this regard, as this will lead to an increased income earning power for the rural communities, and attract more private investments in the energy sector as investments become viable in the rural communities.

Finally, the FGN needs to curb corruption currently ravaging the country. This can be done by building strong anti-corruption institutions and allowing for the tenets of due process, rule of law, transparency and accountability to be entrenched, thereby, building confidence/trust of foreign private investors and international donor agencies. This way, the country will attract investments into the energy sector and fast-track the process of developing rural energy infrastructure.

6.5.4 Implications for the Private Sector

Given the paradigm shift in the rural electrification reforms of Nigeria away from a solely government funded programme to a Public Private Partnership (PPP), the private sector have a major role to play going forward. Private investors could take advantage of the capital subsidies provided for rural electrification projects by the Rural Electrification Fund (REF). The proposed process for selecting and awarding projects to receive funding from the REF will be designed to maximize transparency, efficiency, competition, and sustainability in the funding process and within the projects themselves. This should provide some comfort for the private sector in terms of investing in rural electrification in Nigeria.

The REA also advocates for tax incentives, investment capital, and low-interest loans for local private producers of rural electrification equipment and materials. This provides an investment opportunity for private investors in the local manufacturing of rural electrification equipment.

In terms of grid-connected electrification, the private sector is already investing in electricity generation and distribution based on the current incentives provided by the Government through the Nigerian Bulk Electricity Trading (NBET) as listed in 5.4 above.

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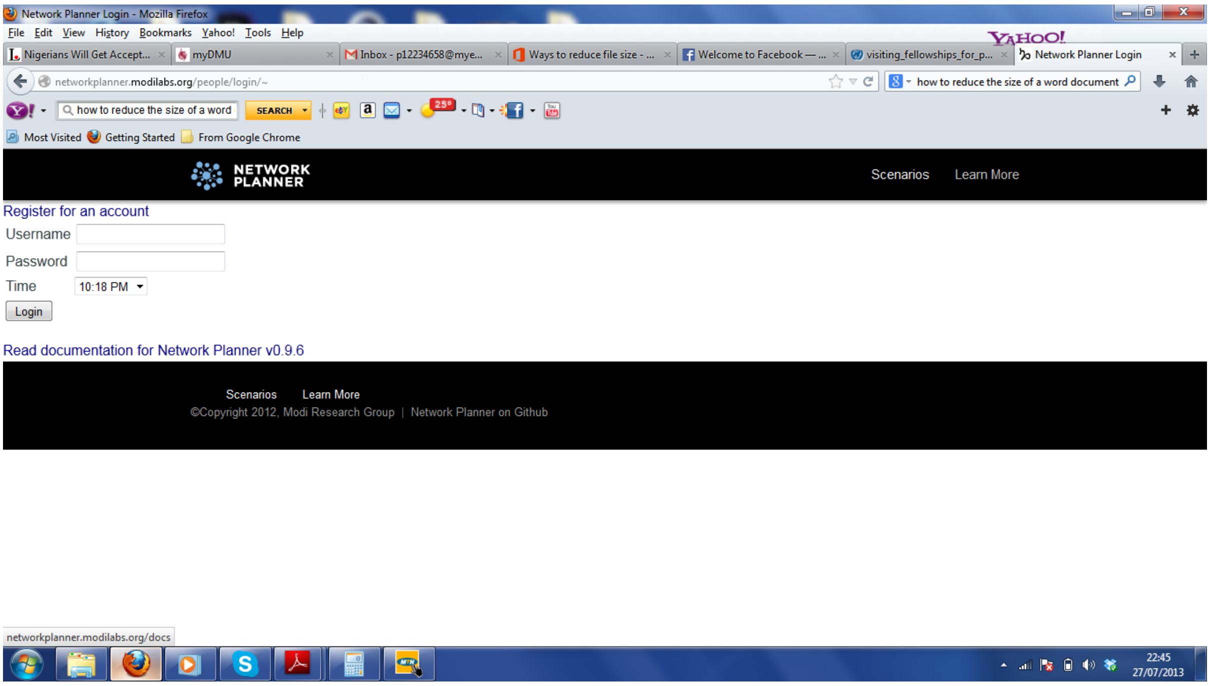
Appendices

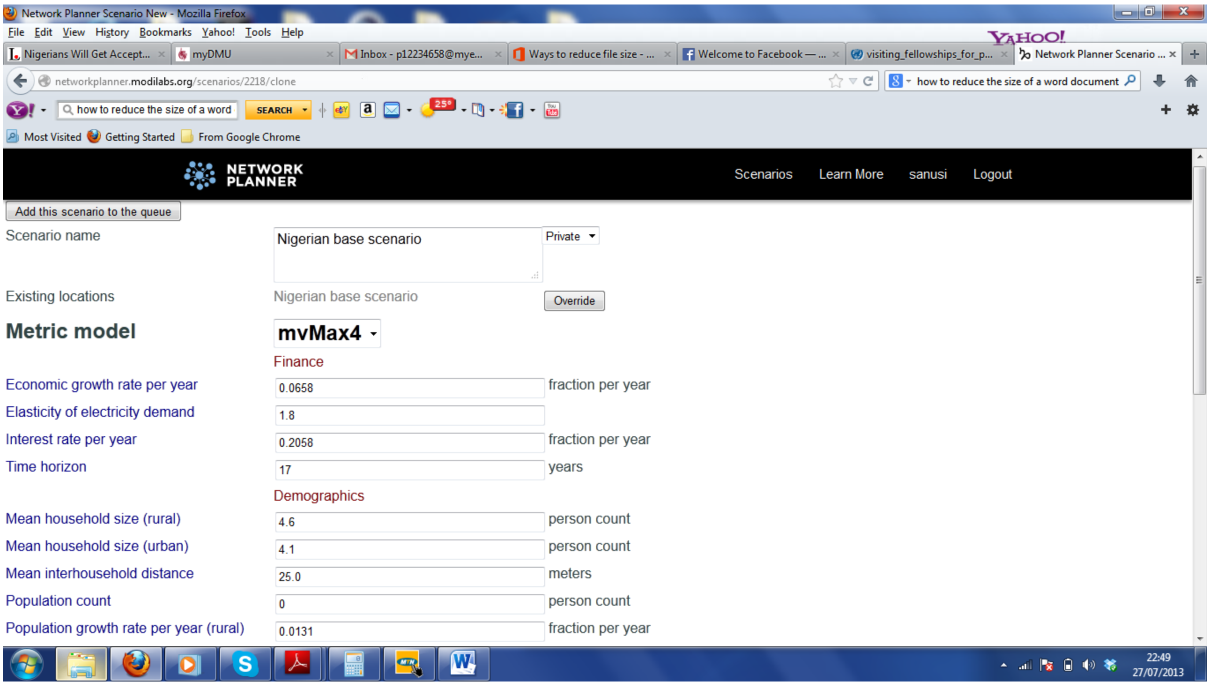
Appendix 1

The following figures are screen-shots from the network planner analysis.

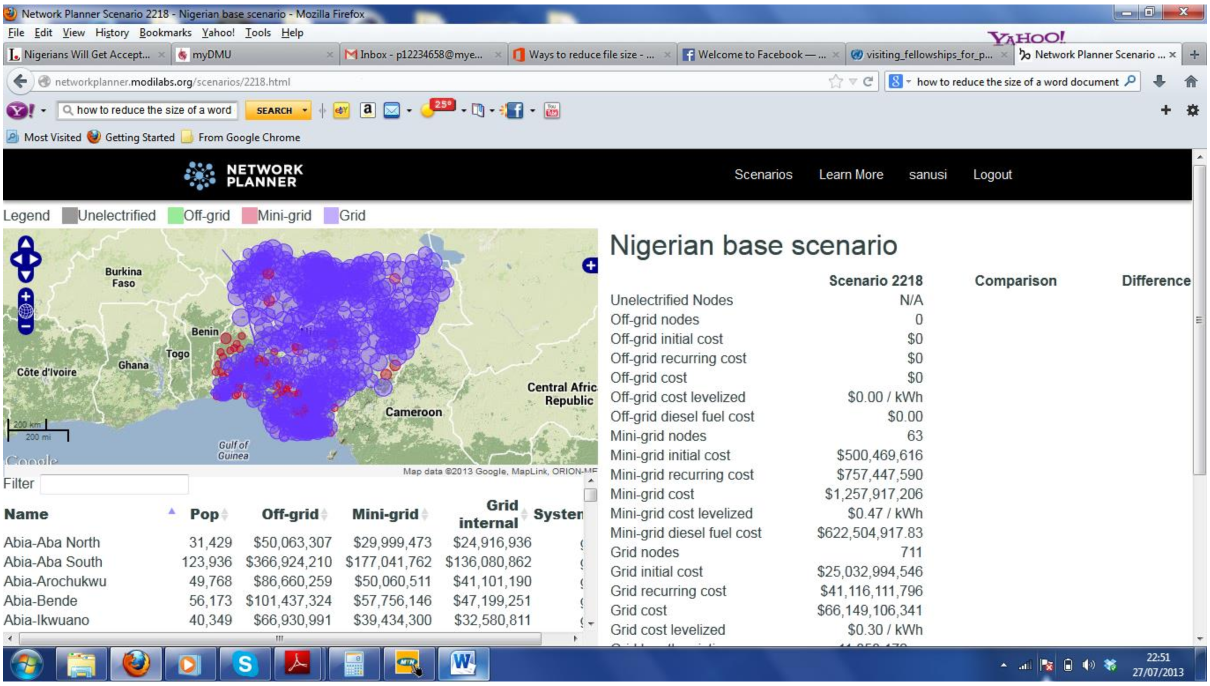
1. Network planner login page:



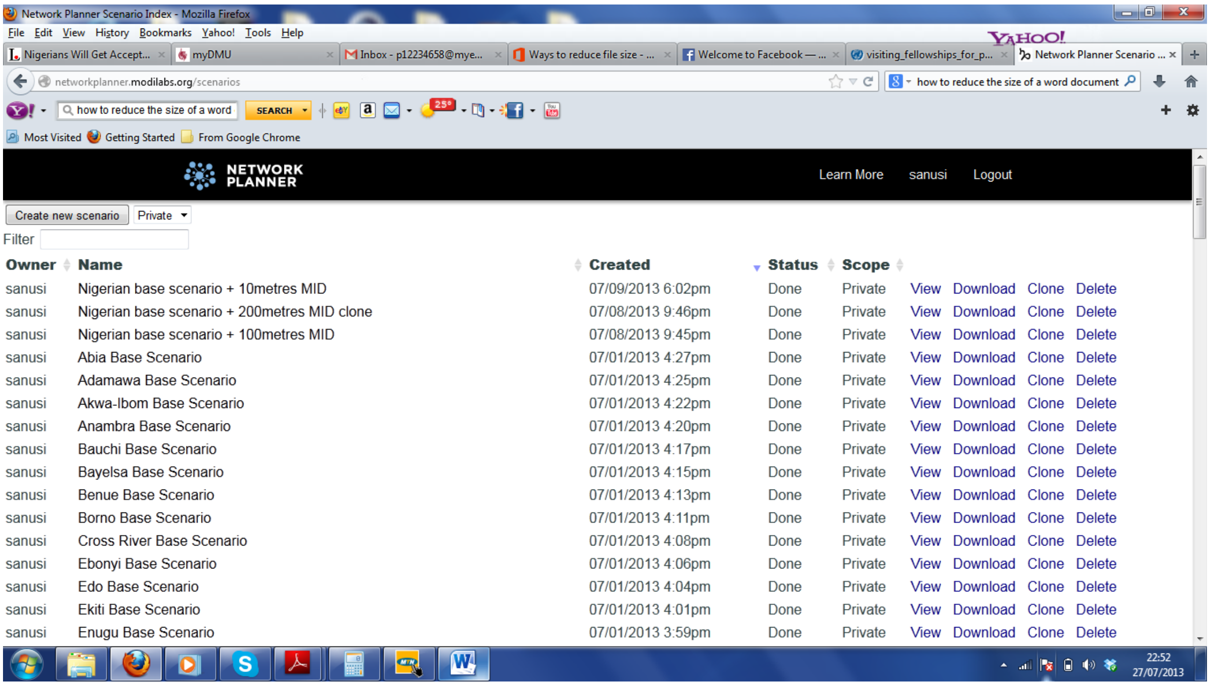
2. Scenario Page:



3. Results Page:

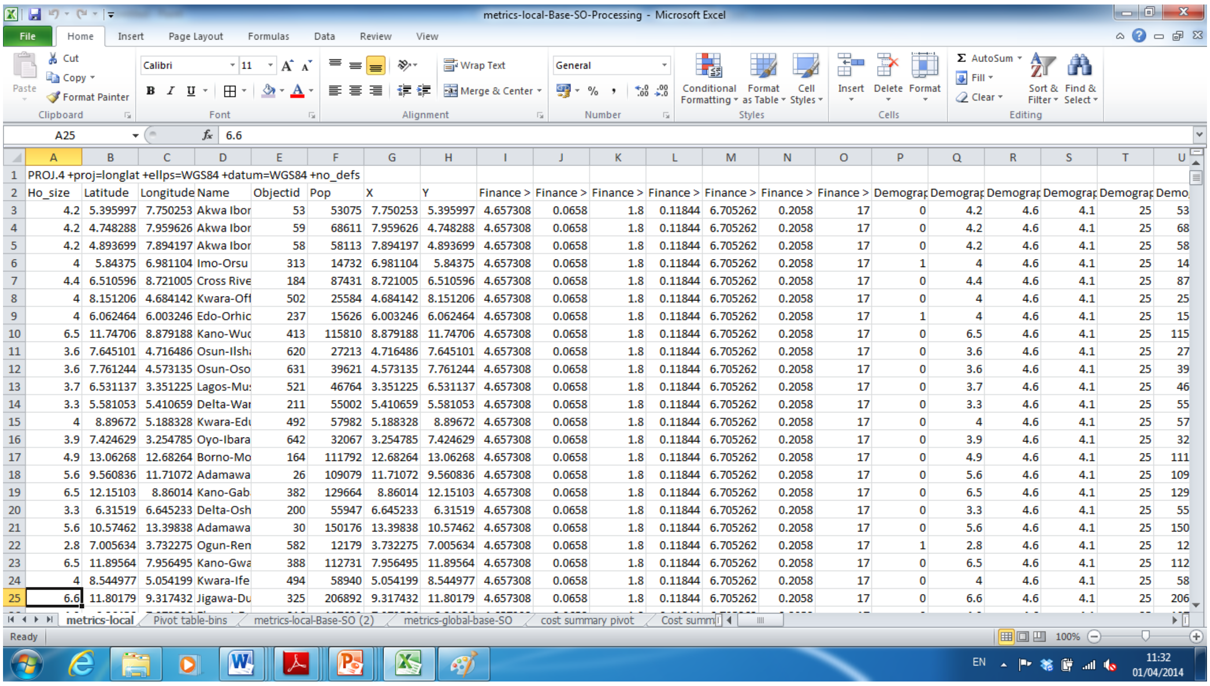


4. Content Page:



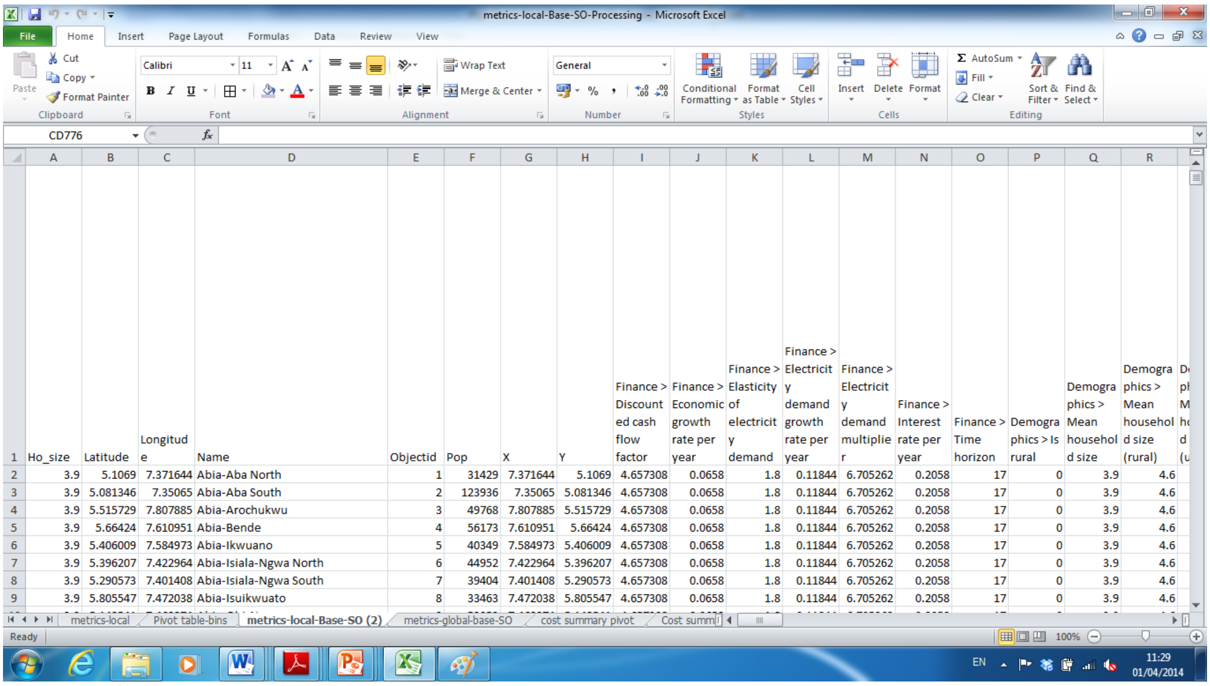
5. Outputs

Metrics Local Output for Base Scenario



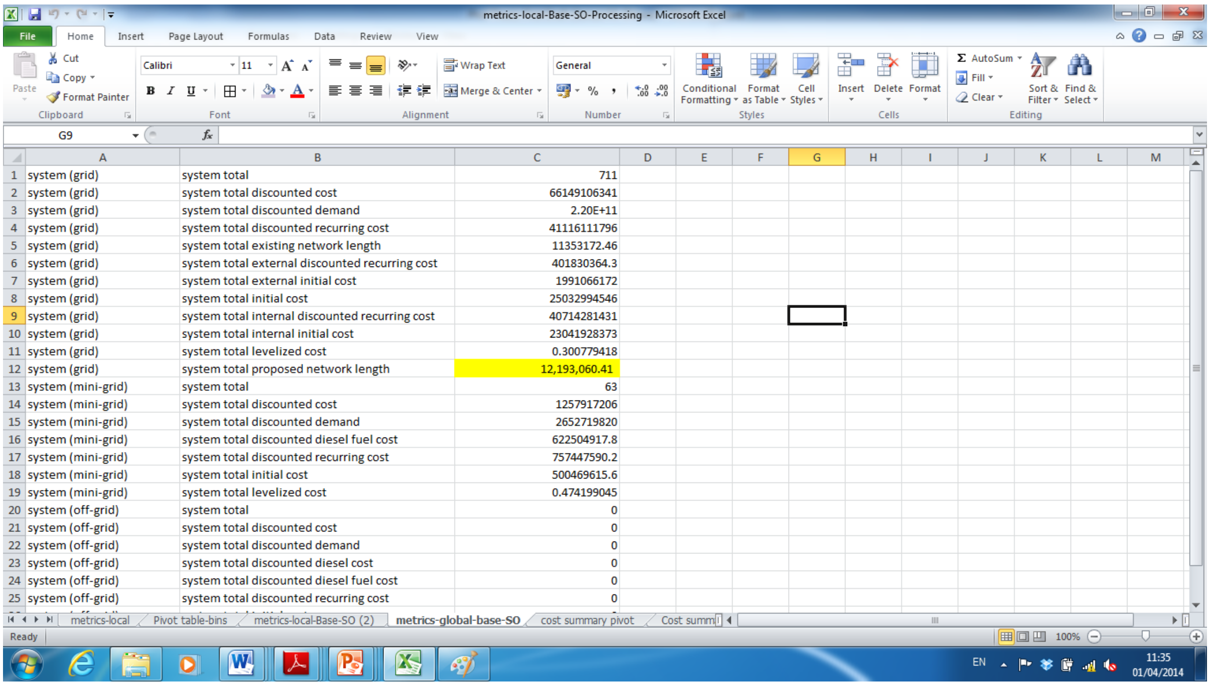
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	PROJ.4 +proj=longlat +ellps=WGS84 +datum=WGS84 +no_defs																				
2	Ho_size	Latitude	Longitude	Name	Objectid	Pop	X	Y	Finance >	Finance >	Finance >	Finance >	Finance >	Finance >	Finance >	Demograp	Demograp	Demograp	Demograp	Demograp	Demo
3	4.2	5.395997	7.750253	Akwa Ibor	53	53075	7.750253	5.395997	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4.2	4.6	4.1	25	53
4	4.2	4.748288	7.959626	Akwa Ibor	59	68611	7.959626	4.748288	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4.2	4.6	4.1	25	68
5	4.2	4.893699	7.894197	Akwa Ibor	58	58113	7.894197	4.893699	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4.2	4.6	4.1	25	58
6	4	5.84375	6.981104	Imo-Orsu	313	14732	6.981104	5.84375	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	1	4	4.6	4.1	25	14
7	4.4	6.510596	8.721005	Cross Rive	184	87431	8.721005	6.510596	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4.4	4.6	4.1	25	87
8	4	8.151206	4.684142	Kwara-Off	502	25584	4.684142	8.151206	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4	4.6	4.1	25	25
9	4	6.062464	6.003246	Edo-Orhic	237	15626	6.003246	6.062464	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	1	4	4.6	4.1	25	15
10	6.5	11.74706	8.879188	Kano-Wuc	413	115810	8.879188	11.74706	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	6.5	4.6	4.1	25	115
11	3.6	7.645101	4.716486	Osun-Ilsh	620	27213	4.716486	7.645101	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.6	4.6	4.1	25	27
12	3.6	7.761244	4.573135	Osun-Oso	631	39621	4.573135	7.761244	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.6	4.6	4.1	25	39
13	3.7	6.531137	3.351225	Lagos-Mu	521	46764	3.351225	6.531137	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.7	4.6	4.1	25	46
14	3.3	5.581053	5.410659	Delta-War	211	55002	5.410659	5.581053	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.3	4.6	4.1	25	55
15	4	8.89672	5.188328	Kwara-Edu	492	57982	5.188328	8.89672	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4	4.6	4.1	25	57
16	3.9	7.424629	3.254785	Oyo-Ibara	642	32067	3.254785	7.424629	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6	4.1	25	32
17	4.9	13.06268	12.68264	Borno-Mo	164	111792	12.68264	13.06268	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4.9	4.6	4.1	25	111
18	5.6	9.560836	11.71072	Adamawa	26	109079	11.71072	9.560836	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	5.6	4.6	4.1	25	109
19	6.5	12.15103	8.86014	Kano-Gab	382	129664	8.86014	12.15103	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	6.5	4.6	4.1	25	129
20	3.3	6.31519	6.645233	Delta-Osh	200	55947	6.645233	6.31519	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.3	4.6	4.1	25	55
21	5.6	10.57462	13.39838	Adamawa	30	150176	13.39838	10.57462	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	5.6	4.6	4.1	25	150
22	2.8	7.005634	3.732275	Ogun-Ren	582	12179	3.732275	7.005634	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	1	2.8	4.6	4.1	25	12
23	6.5	11.89564	7.956495	Kano-Gwa	388	112731	7.956495	11.89564	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	6.5	4.6	4.1	25	112
24	4	8.544977	5.054199	Kwara-Ife	494	58940	5.054199	8.544977	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	4	4.6	4.1	25	58
25	6.6	11.80179	9.317432	Jigawa-Du	325	206892	9.317432	11.80179	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	6.6	4.6	4.1	25	206

Metrics Local Output Processing for Base Scenario



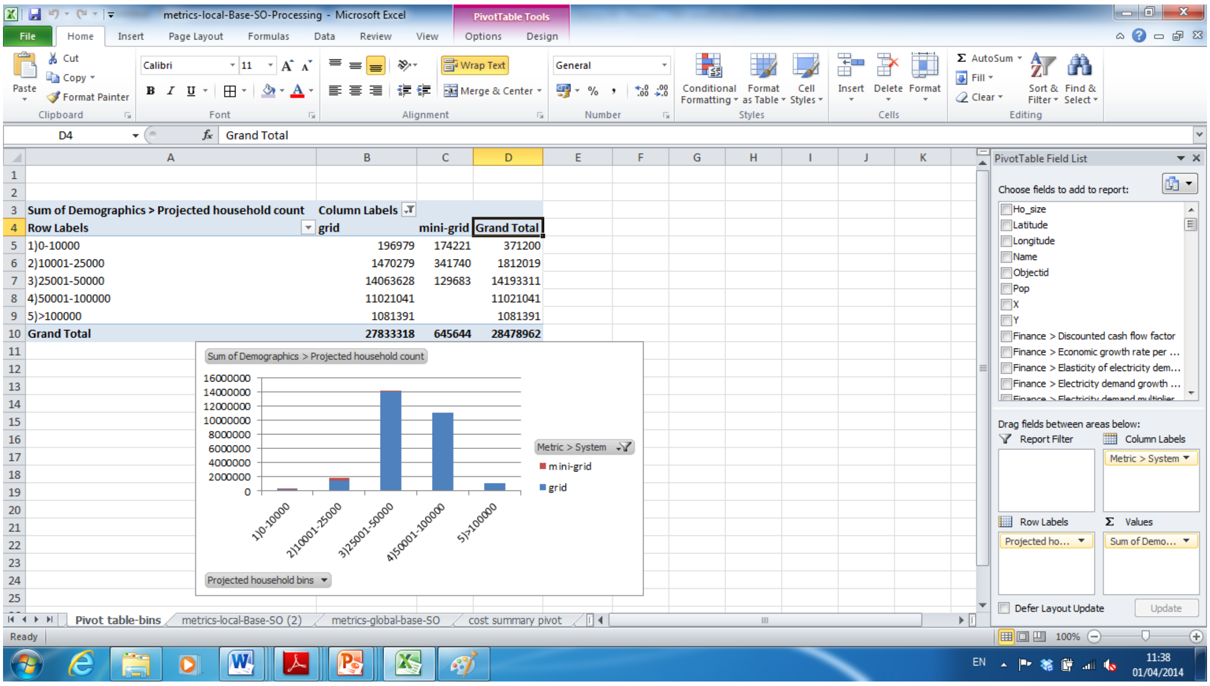
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Ho_size	Latitude	Longitude	Name	Objectid	Pop	X	Y	Finance > Discounted cash flow factor	Finance > Economic growth rate per year	Finance > Elasticity of electricity demand	Finance > Electricity demand growth rate per year	Finance > Electricity demand multiplier	Finance > Interest rate per year	Finance > Time horizon	Demographics > Is rural	Demographics > Mean household size	Demographics > Mean household size (rural)
2	3.9	5.1069	7.371644	Abia-Aba North	1	31429	7.371644	5.1069	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6
3	3.9	5.081346	7.35065	Abia-Aba South	2	123936	7.35065	5.081346	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6
4	3.9	5.515729	7.807885	Abia-Arochukwu	3	49768	7.807885	5.515729	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6
5	3.9	5.66424	7.610951	Abia-Bende	4	56173	7.610951	5.66424	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6
6	3.9	5.406009	7.584973	Abia-Ikwuano	5	40349	7.584973	5.406009	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6
7	3.9	5.396207	7.422964	Abia-Isiala-Ngwa North	6	44952	7.422964	5.396207	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6
8	3.9	5.290573	7.401408	Abia-Isiala-Ngwa South	7	39404	7.401408	5.290573	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6
9	3.9	5.805547	7.472038	Abia-Isuikwuato	8	33463	7.472038	5.805547	4.657308	0.0658	1.8	0.11844	6.705262	0.2058	17	0	3.9	4.6

Metrics Global Output for Base Scenario



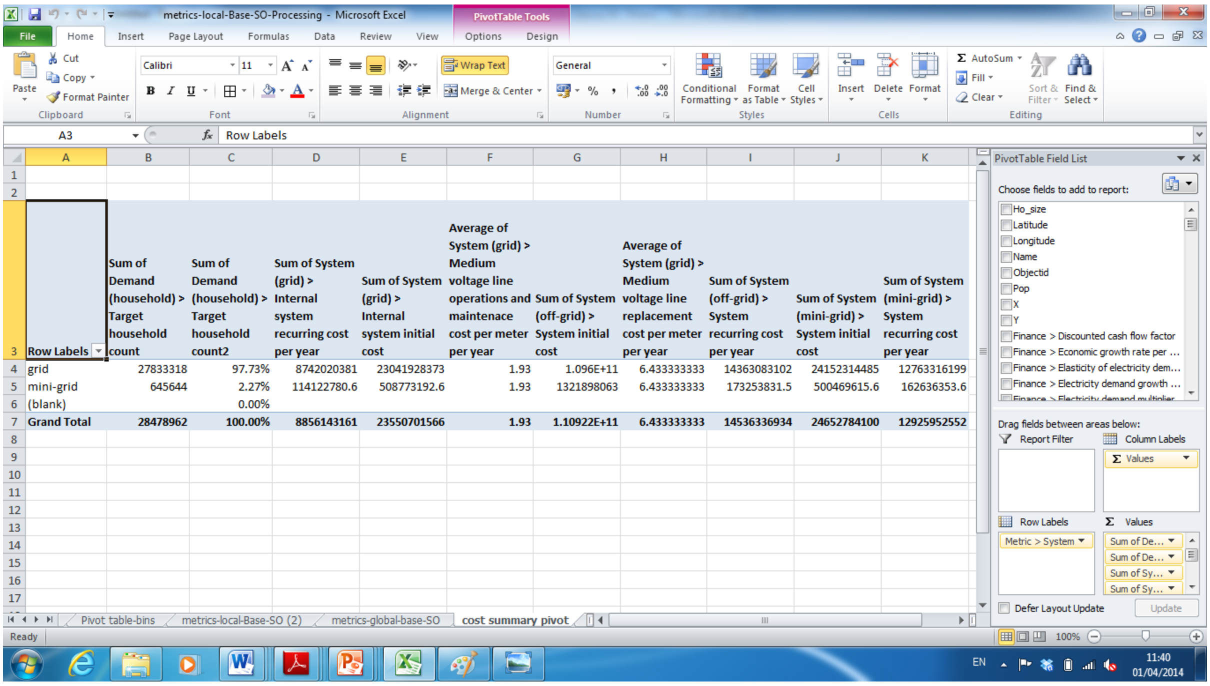
	A	B	C
1	system (grid)	system total	711
2	system (grid)	system total discounted cost	66149106341
3	system (grid)	system total discounted demand	2.20E+11
4	system (grid)	system total discounted recurring cost	41116111796
5	system (grid)	system total existing network length	11353172.46
6	system (grid)	system total external discounted recurring cost	401830364.3
7	system (grid)	system total external initial cost	1991066172
8	system (grid)	system total initial cost	25032994546
9	system (grid)	system total internal discounted recurring cost	40714281431
10	system (grid)	system total internal initial cost	23041928373
11	system (grid)	system total levelized cost	0.300779418
12	system (grid)	system total proposed network length	12,193,060.41
13	system (mini-grid)	system total	63
14	system (mini-grid)	system total discounted cost	1257917206
15	system (mini-grid)	system total discounted demand	2652719820
16	system (mini-grid)	system total discounted diesel fuel cost	622504917.8
17	system (mini-grid)	system total discounted recurring cost	757447590.2
18	system (mini-grid)	system total initial cost	500469615.6
19	system (mini-grid)	system total levelized cost	0.474199045
20	system (off-grid)	system total	0
21	system (off-grid)	system total discounted cost	0
22	system (off-grid)	system total discounted demand	0
23	system (off-grid)	system total discounted diesel cost	0
24	system (off-grid)	system total discounted diesel fuel cost	0
25	system (off-grid)	system total discounted recurring cost	0

Pivot Bins Processing for Base Scenario

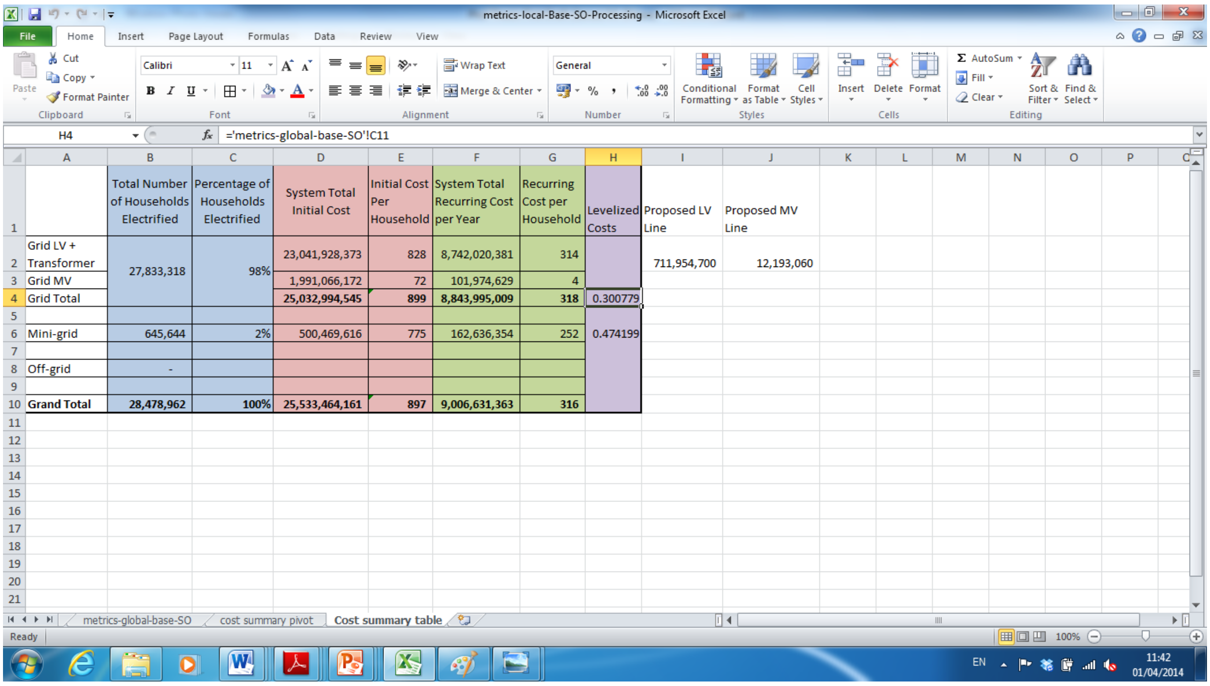


Sum of Demographics > Projected household count	Column Labels		
Row Labels	grid	mini-grid	Grand Total
1)0-10000	196979	174221	371200
2)10001-25000	1470279	341740	1812019
3)25001-50000	14063628	129683	14193311
4)50001-100000	11021041		11021041
5)>100000	1081391		1081391
Grand Total	27833318	645644	28478962

Cost Summary Pivot Processing for Base Scenario



Cost Summary Table Being Processed for the Base Scenario



Appendix 2

1. Abia State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost	Initial Cost Per House hold ($)	System Total Recurring Cost per Year	Recurring Cost per Household	Levelized Costs
Grid LV + Transformer			322,538,097	796	82,464,012	203	
Grid MV			33,002,982	81	1,518,358	4	
Grid Total	405,343	98%	355,541,079	877	83,982,370	207	0.37994
Mini-grid	6,280	2%	4,806,660	765	1,444,968	230	0.495372
Off-grid	-						
Grand Total	**411,623**	**100%**	**360,347,739**	**875**	**85,427,339**	**208**	

2. Adamawa State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,048,161	98%	881,580,470	841	376,914,462	360	**0.285608**
Grid MV			87,146,860	83	4,333,935	4	
Grid Total			968,727,330	924	381,248,397	364	
Mini-grid	17,506	2%	13,675,138	781	4,647,138	265	**0.462966**
Off-grid							
Grand Total	**1,065,667**	**100%**	**982,402,468**	**922**	**385,895,535**	**362**	

3. Akwa Ibom State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost	Initial Cost Per House -hold	System Total Recurring Cost per Year	Recurring Cost per Household	Levelized Costs
Grid LV + Transformer	972903	100%	780061710.9	801	218279354	224.358804	**0.351192**
Grid MV			46907871.93	48	2333333.068	2.39832036	
Grid Total							
Mini-grid							
Off-grid							
Grand Total	**972903**	**100%**	**826969582.8**	**850**	**220612687**	**226.757125**	

4. Anambra State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	266483	90%	210,054,118	788	47,342,947	178	**0.408453**
Grid MV			16,117,924	60	882,830	3	
Grid Total			226,172,042	849	48,225,777	181	
Mini-grid	29508	10%	22,680,998	769	7,005,282	237	**0.48776**
Off-grid							
Grand Total	**295991**	**100%**	**248,853,040**	**841**	**55,231,059**	**187**	

5. Bauchi State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	927857	98%	792572823	854	375555916.6	404.756247	**0.2718006**
Grid MV			68737686.5	74	4256444.173	4.58739243	
Grid Total			861310510	928	379812360.8	409.343639	
Mini-grid	23511	2%	18807970.5	799	7224590.591	307.285551	**0.4353174**
Off-grid	0						
Grand Total	**951368**	**100%**	**880118480**	**925**	**387036951.4**	**406.821494**	

6. Bayelsa State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	315937	100%	254,881,646	807	76,283,696	241	**0.34624966**
Grid MV			28,927,164	92	1,350,783	4	
Grid Total			283,808,810	898	77,634,479	246	
Mini-grid							
Off-grid							
Grand Total	**315937**	**100%**	**283,808,810**	**898**	**77,634,479**	**246**	

7. Benue State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,198,680	100%	1,007,174,367	840	427,599,323	357	
Grid MV			71,977,172	60	4,589,150	4	
Grid Total			1,079,151,540	900	432,188,473	361	**0.28348**
Mini-grid							
Off-grid							
Grand Total	**1,198,680**	**100%**	**1,079,151,540**	**900**	**432,188,473**	**361**	

8. Borno State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,589,400	100%	1,385,705,952	872	739,882,336	466	**0.261240**
Grid MV			154,610,218	97	7,390,659	5	
Grid Total			1,540,316,170	969	747,272,995	470	
Mini-grid							
Off-grid							
Grand Total	**1,589,400**	**100%**	**1,540,316,170**	**969**	**747,272,995**	**470**	

9. Cross River State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per Household ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	627,496	97%	506,160,622	807	151,266,215	241	0.354437
Grid MV			81,673,379	130	3,726,464	6	
Grid Total			587,834,000	937	154,992,679	247	
Mini-grid	22,632	3%	17,513,703	774	5,633,018	249	0.476890
Off-grid							
Grand Total	**650,128**	**100%**	**605,347,703**	**931**	**160,625,697**	**247**	

10. Delta State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,145,787	100%	923,319,693	806	273,084,442	238	0.338307
Grid MV			47,215,653	41	2,096,007	2	
Grid Total			970,535,346	847	275,180,449	240	
Mini-grid							
Off-grid							
Grand Total	**1,145,787**	**100%**	**970,535,346**	**847**	**275,180,449**	**240**	

11. Ebonyi State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer			526,583,923	826	196,512,803	308	
Grid MV	637,375	100%	33,215,953	52	1,628,605	3	**0.3002676**
Grid Total			559,799,876	878	198,141,408	311	
Mini-grid							
Off-grid							
Grand Total	**637,375**	**100%**	**559,799,876**	**878**	**198,141,408**	**311**	

12. Edo State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer		69%	57,599,119	786	12,339,443	168	
Grid MV	73,322		2,535,176	35	219,715	3	**0.4157409**
Grid Total			60,134,295	820	12,559,158	171	
Mini-grid	33,013	31%	25,229,721	764	7,498,789	227	**0.4987196**
Off-grid							
Grand Total	106,335	100%	85,364,016	803	20,057,947	189	

13. Ekiti State Cost Summary Table

	Total Number of Households Electrified	**Percentage of Households Electrified**	**System Total Initial Cost ($)**	**Initial Cost Per House -hold ($)**	**System Total Recurring Cost per Year ($)**	**Recurring Cost per Household ($)**	**Levelized Costs ($)**
Grid LV + Transformer	309,175	95%	243,738,675	788	55,057,119	178	0.4221807
Grid MV			34,025,720	110	1,590,622	5	
Grid Total			277,764,394	898	56,647,741	183	
							0.4918435
Mini-grid	16,764	5%	12,856,025	767	3,913,079	233	
Off-grid							
Grand Total	**325,939**	**100%**	**290,620,419**	**892**	**60,560,821**	**186**	

14. Enugu Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	770,522	100%	626,878,252	814	204,157,299	265	**0.321172**
Grid MV			34,882,359	45	1,755,470	2	
Grid Total			661,760,612	859	205,912,769	267	
Mini-grid							
Off-grid							
Grand Total	**770,522**	**100%**	**661,760,612**	**859**	**205,912,769**	**267**	

15. FCT-Abuja Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	218,231	89%	195,655,472	897	120,151,890	551	**0.244045**
Grid MV			11,187,246	51	647,300	3	
Grid Total			206,842,718	948	120,799,190	554	
Mini-grid	27,209	11%	21,096,650	775	6,865,354	252	**0.473840**
Off-grid							
Grand Total	**245,440**	**100%**	**227,939,368**	**929**	**127,664,544**	**520**	

16. Gombe State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	601,375	100%	509,656,490	847	229,521,765	382	0.274387
Grid MV			27,622,123	46	1,542,659	3	
Grid Total			537,278,614	893	231,064,423	384	
Mini-grid							
Off-grid							
Grand Total	**601,375**	**100%**	**537,278,614**	**893**	**231,064,423**	**384**	

17. Imo State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	127,620	65%	100,152,635	785	21,128,221	166	0.434825
Grid MV			10,213,892	80	640,425	5	
Grid Total			110,366,526	865	21,768,646	171	
Mini-grid	67,455	35%	51,651,612	766	15,568,083	231	0.494631
Off-grid							
Grand Total	**195,075**	**100%**	**162,018,139**	**831**	**37,336,729**	**191**	

18. Jigawa State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,060,396	100%	886,782,015	836	363,768,018	343	0.290381
Grid MV			81,871,272	77	4,293,415	4	
Grid Total			968,653,287	913	368,061,433	347	
Mini-grid							
Off-grid							
Grand Total	**1,060,396**	**100%**	**968,653,287**	**913**	**368,061,433**	**347**	

19. Kaduna State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,248,819	100%	1,058,743,870	848	477,970,373	383	0.2741598
Grid MV			57,987,281	46	3,417,652	3	
Grid Total			1,116,731,151	894	481,388,025	385	
Mini-grid							
Off-grid							
Grand Total	**1,248,819**	**100%**	**1,116,731,151**	**894**	**481,388,025**	**385**	

20. Kano State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,729,744	100%	1,451,927,624	839	611,923,593	354	0.282498
Grid MV			78,856,320	46	4,294,791	2	
Grid Total			1,530,783,945	885	616,218,384	356	
Mini-grid							
Off-grid							
Grand Total	**1,729,744**	**100%**	**1,530,783,945**	**885**	**616,218,384**	**356**	

21. Katsina State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,405,492	100%	1,158,236,712	824	423,176,101	301	0.3068200
Grid MV			423,176,101	301	4,976,217	4	
Grid Total			1,581,412,812	1,125	428,152,317	305	
Mini-grid							
Off-grid							
Grand Total	**1,405,492**	**100%**	**1,581,412,812**	**1,125**	**428,152,317**	**305**	

22. Kebbi State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	729,313	97%	597,970,369	820	209,110,124	287	0.316363
Grid MV			63,964,465	88	3,887,637	5	
Grid Total			661,934,834	908	212,997,761	292	
	21,139	3%	16,656,301	788	5,927,735	280	0.452054
Mini-grid							
Off-grid							
Grand Total	**750,452**	**100%**	**678,591,135**	**904**	**218,925,495**	**292**	

23. Kogi State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	696,535	92%	560,501,642	805	163,268,525	234	0.356472
Grid MV			78,689,103	113	3,895,108	6	
Grid Total			639,190,745	918	167,163,633	240	
	60,198	8%	46,843,981	778	15,575,284	259	0.468358
Mini-grid							
Off-grid							
Grand Total	**756,733**	**100%**	**686,034,726**	**907**	**182,738,917**	**241**	

24. Kwara State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	245,496	76%	195,167,080	795	49,333,740	201	0.376302
Grid MV			13,622,458	55	1,180,613	5	
Grid Total			208,789,538	850	50,514,353	206	
	78,053	24%	60,605,734	776	19,893,762	255	0.471616
Mini-grid							
Off-grid							
Grand Total	**323,549**	**100%**	**269,395,272**	**833**	**70,408,115**	**218**	

25. Lagos State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	328,417	96%	259,822,742	791	61,627,021	188	0.3822958
Grid MV			5,639,635	17	311,830	1	
Grid Total			265,462,377	808	61,938,851	189	
	14,611	4%	11,174,609	765	3,344,019	229	0.4966706
Mini-grid							
Off-grid							
Grand Total	**343,028**	**100%**	**276,636,987**	**806**	**65,282,870**	**190**	

26. Nasarawa State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	439,943	96%	359,551,381	817	122,149,115	278	0.3251249
Grid MV			48,111,802	109	2,945,856	7	
Grid Total			407,663,184	927	125,094,971	284	
	17,799	4%	13,858,623	779	4,621,261	260	0.4676478
Mini-grid							
Off-grid							
Grand Total	**457,742**	**100%**	**421,521,807**	**921**	**129,716,232**	**283**	

27. Niger State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,098,726	100%	909,557,702	828	345,001,873	314	**0.2961937**
Grid MV			45,227,365	41	3,393,314	3	
Grid Total			954,785,067	869	348,395,187	317	
Mini-grid							
Off-grid							
Grand Total	**1,098,726**	**100%**	**954,785,067**	**869**	**348,395,187**	**317**	

28. Ogun State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	485,305	94%	386,465,519	796	99,773,351	206	**0.3665448**
Grid MV			17,789,956	37	1,277,046	3	
Grid Total			404,255,475	833	101,050,397	208	
	30,158	6%	23,119,553	767	7,025,863	233	**0.4922674**
Mini-grid							
Off-grid							
Grand Total	**515,463**	**100%**	**427,375,028**	**829**	**108,076,260**	**210**	

29. Ondo State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	828,557	100%	665,713,874	803	190,701,639	230	**0.347262**
Grid MV			43,840,045	53	2,228,904	3	
Grid Total			709,553,918	856	192,930,543	233	
Mini-grid							
Off-grid							
Grand Total	**828,557**	**100%**	**709,553,918**	**856**	**192,930,543**	**233**	

30. Osun State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House-hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	440,872	96%	346,977,807	787	76,477,406	173	**0.413573**
Grid MV			24,479,055	56	1,405,974	3	
Grid Total			371,456,862	843	77,883,381	177	
	16,732	4%	12,803,735	765	3,840,348	230	**0.496050**
Mini-grid							
Off-grid							
Grand Total	**457,604**	**100%**	**384,260,597**	**840**	**81,723,728**	**179**	

31. Oyo State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	686,737	79%	547,737,942	798	144,168,335	210	0.36574
Grid MV			35,722,307	52	2,444,311	4	
Grid Total			583,460,249	850	146,612,646	213	
	179,154	21%	138,462,941	773	44,231,119	247	0.47866
Mini-grid							
Off-grid							
Grand Total	**865,891**		**721,923,190**	**834**	**190,843,765**	**220**	

32. Plateau State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	829,789	100%	705,408,741	850	324,184,464	391	0.276805
Grid MV			71,224,398	86	3,301,765	4	
Grid Total			776,633,139	936	327,486,229	395	
Mini-grid							
Off-grid							
Grand Total	**829,789**	**100%**	**776,633,139**	**936**	**327,486,229**	**395**	

33. Rivers State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	797,321	100%	646,009,528	810	202,038,827	253	0.329379
Grid MV			39,895,546	50	2,163,923	3	
Grid Total			685,905,075	860	204,202,750	256	
Mini-grid							
Off-grid							
Grand Total	**797,321**	**100%**	**685,905,075**	**860**	**204,202,750**	**256**	

34. Sokoto State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	1,007,741	98%	839,212,206	833	333,556,668	331	0.296891
Grid MV			92,445,954	92	4,900,868	5	
Grid Total			931,658,160	925	338,457,536	336	
	18,972	2%	14,869,811	784	5,144,836	271	0.458644
Mini-grid							
Off-grid							
Grand Total	**1,026,713**	**100%**	**946,527,971**	**922**	**343,602,372**	**335**	

35. Taraba State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	875,757	96%	738,134,363	843	320,299,766	366	0.290712
Grid MV			120,679,872	138	5,713,208	7	
Grid Total			858,814,235	981	326,012,974	372	
		4%					
Mini-grid	34,894		28,240,221	809	11,450,821	328	0.424386
Off-grid							
Grand Total	**910,651**	**100%**	**887,054,455**	**974**	**337,463,795**	**371**	

36. Yobe State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	667,338	97%	555,459,178	832	219,924,428	330	0.292930
Grid MV			40,296,224	60	2,472,860	4	
Grid Total			595,755,402	893	222,397,289	333	
		3%					
Mini-grid	18,009		14,115,051	784	4,883,945	271	0.458630
Off-grid							
Grand Total	**685,347**	**100%**	**609,870,453**	**890**	**227,281,234**	**332**	

37. Zamfara State Cost Summary Table

	Total Number of Households Electrified	Percentage of Households Electrified	System Total Initial Cost ($)	Initial Cost Per House -hold ($)	System Total Recurring Cost per Year ($)	Recurring Cost per Household ($)	Levelized Costs ($)
Grid LV + Transformer	907,400	100%	778,745,349	858	379,848,800	419	**0.2692133**
Grid MV			72,924,857	80	3,582,620	4	
Grid Total			851,670,206	939	383,431,420	423	
Mini-grid							
Off-grid							
Grand Total	**907,400**	**100%**	**851,670,206**	**939**	**383,431,420**	**423**	

APPENDIX 3

Stakeholders Interview Questions

DE MONTFORT UNIVERSITY LEICESTER – UK

Institute of Energy and Sustainable Development (IESD)

QUESTIONNAIRE ON FINANCING RURAL ENERGY PROJECTS IN DEVELOPING COUNTRIES: A CASE STUDY OF NIGERIA

This questionnaire has been designed to elicit relevant information on financing rural electrification in Nigeria. The research is purely for academic purposes and any information received will be treated with utmost confidentiality.

Questionnaire for Stakeholders within the NESI

D) BACKGROUND INFORMATION

1. Name…………………………………………………………………………………
2. Company/Agency……………………………………………………………………
3. Position……………………………………………………………………………

E) TECHNICAL INFORMATION

4. Have you or your company/agency ever conducted any technical study/survey to determine appropriate technology choices or combination of technologies to be used in generating/supplying electricity for rural electrification in Nigeria?

Yes [ ]   No [ ]

5. If yes, what were your findings? If No, go to question 7.

………

………

6. What methodology/model was employed?

………

F) COSTS INFORMATION

7. Have you or your agency/company conducted any study to determine the cost of expanding energy access to areas that currently do not have access at any level (village, ward, state or national) in Nigeria?

Yes [ ] No [ ]

8. If yes, what were your findings? If No, go to question 10.

…….

…….

9. What methodology/model was employed?

……

D. BARRIERS

10. In your opinion and given your experience within the industry, what do you think are barriers to rural electrification in Nigeria?

……

……

……

E. FINANCING OPTIONS

11. In your opinion and given your experience within the industry, what would you proffer as financing options for rural electrification in Nigeria?

……

……

……

Thank you very much for your time and participation

APPENDIX 4

1. Relevant Tables and Data

SOURCE: IEA, World Energy Outlook 2013

Table 2: **Electricity access in 2011 - Africa**

Region	Population without electricity (millions)	Electrification rate (%)	Urban electrification rate (%)	Rural electrification rate (%)
Sub-Saharan Africa	**599**	**31.8**	**55.2**	**18.3**
Angola	*12*	*38*	*58*	*8*
Benin	*7*	*28*	*55*	*6*
Botswana	*1*	*46*	*68*	*10*
Burkina Faso	*14*	*13*	*39*	*4*
Cameroon	*9*	*54*	*88*	*17*
Congo, Rep	*3*	*38*	*54*	*10*
Cote d'Ivoire	*8*	*59*	*85*	*32*
DR of Congo	*62*	*9*	*26*	*0*
Eritrea	*4*	*32*	*86*	*17*
Ethiopia	*65*	*23*	*85*	*11*
Gabon	*1*	*60*	*64*	*34*
Ghana	*7*	*72*	*90*	*52*
Kenya	*34*	*19*	*58*	*7*
Lesotho	*2*	*19*	*45*	*9*
Madagascar	*18*	*14*	*62*	*-9*
Malawi	*14*	*7*	*37*	*1*
Mauritius	*0*	*99*	*100*	*99*
Mozambique	*19*	*20*	*55*	*5*
Namibia	*1*	*60*	*83*	*46*
Nigeria	*85*	*48*	*35*	*61*
Senegal	*6*	*57*	*88*	*33*
South Africa	*8*	*85*	*96*	*67*
Sudan	*25*	*29*	*57*	*14*
Tanzania	*39*	*15*	*46*	*4*
Togo	*5*	*27*	*35*	*21*
Uganda	*30*	*15*	*55*	*7*
Zambia	*11*	*22*	*51*	*3*
Zimbabwe	*8*	*37*	*83*	*8*
Other sub-Saharan Africa	*105*	*13*	*34*	*4*
North Africa	**1**	**99.4**	**100.0**	**98.7**
Algeria	*0*	*99*	*100*	*98*
Egypt	*0*	*100*	*100*	*99*
Libya	*0*	*100*	*100*	*99*
Morocco	*0*	*99*	*100*	*97*
Tunisia	*0*	*100*	*100*	*99*
Africa	**600**	**42.6**	**65.2**	**27.8**

SOURCE: IEA, World Energy Outlook 2013

Table 3: **Electricity access in 2011 - Developing Asia**

Region	Population without electricity millions	Electrification rate %	Urban electrification rate %	Rural electrification rate %
China	**3**	**99.8**	**100.0**	**99.6**
India	**306**	**75.3**	**93.9**	**66.9**
Southeast Asia	**134**	**77.6**	**90.5**	**67.2**
Brunei Darussalam	*0*	*100*	*100*	*99*
Cambodia	*9*	*34*	*97*	*18*
Indonesia	*66*	*73*	*85*	*60*
Laos	*1*	*78*	*93*	*70*
Malaysia	*0*	*100*	*100*	*99*
Myanmar	*25*	*49*	*89*	*29*
Philippines	*28*	*70*	*89*	*52*
Singapore	*0*	*100*	*100*	*100*
Thailand	*1*	*99*	*100*	*99*
Vietnam	*4*	*96*	*100*	*94*
Rest of developing Asia	**172**	**61.4**	**81.9**	**51.7**
Bangladesh	*61*	*60*	*90*	*48*
DPR Korea	*18*	*26*	*36*	*11*
Mongolia	*0*	*88*	*98*	*67*
Nepal	*7*	*76*	*97*	*72*
Pakistan	*56*	*69*	*88*	*57*
Sri Lanka	*3*	*85*	*96*	*84*
Other Asia	*27*	*32*	*59*	*22*
Developing Asia	**615**	**83.1**	**95.0**	**74.9**

SOURCE: IEA, World Energy Outlook 2013

Table 4: **Electricity access in 2011 - Latin America**

Region	Population without electricity millions	Electrification rate %	Urban electrification rate %	Rural electrification rate %
Argentina	*1.1*	*97*	*100*	*68*
Bolivia	*1.3*	*87*	*99*	*62*
Brazil	*1.4*	*99*	*100*	*96*
Colombia	*1.2*	*97*	*99*	*91*
Costa Rica	*0.0*	*99*	*100*	*98*
Cuba	*0.3*	*98*	*99*	*92*
Dominican Republic	*0.4*	*96*	*99*	*89*
Ecuador	*0.7*	*96*	*98*	*90*
El Salvador	*0.5*	*92*	*97*	*82*
Guatemala	*2.7*	*82*	*95*	*69*
Haiti	*7.3*	*28*	*44*	*9*
Honduras	*1.3*	*83*	*95*	*70*
Jamaica	*0.2*	*93*	*98*	*87*
Nicaragua	*1.3*	*78*	*98*	*50*
Panama	*0.4*	*88*	*97*	*62*
Paraguay	*0.1*	*98*	*100*	*96*
Peru	*3.0*	*90*	*98*	*60*
Trinidad and Tobago	*0.0*	*99*	*100*	*99*
Uruguay	*0.0*	*99*	*100*	*87*
Venezuela	*0.1*	*100*	*100*	*96*
Other Latin America	*0.2*	*91*	*93*	*89*
Latin America	**24**	**94.8**	**98.5**	**81.1**

SOURCE: IEA, World Energy Outlook 2013

Table 5: **Electricity access in 2011 - Middle East**

Region	Population without electricity millions	Electrification rate %	Urban electrification rate %	Rural electrification rate %
Bahrain	*0.0*	*99*	*100*	*95*
Iran	*1.3*	*98*	*100*	*95*
Iraq	*0.7*	*98*	*100*	*94*
Jordan	*0.0*	*99*	*100*	*99*
Kuwait	*0.0*	*100*	*100*	*100*
Lebanon	*0.0*	*100*	*100*	*99*
Oman	*0.1*	*98*	*100*	*93*
Qatar	*0.0*	*100*	*100*	*69*
Saudi Arabia	*0.3*	*99*	*100*	*94*
Syria	*1.5*	*93*	*100*	*84*
United Arab Emirates	*0.0*	*100*	*100*	*100*
Yemen	*14.9*	*40*	*75*	*23*
Middle East	**19**	**91.0**	**98.5**	**75.8**

2. Percentage Distribution of Households Monthly Income/Allowances, 2008

State	N'000									Percent				
	1-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200	201-400	401-600	601-800	Above 800
Abia	80.7	13.8	3.7	1.0	0.4	0.0	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.0
Adamawa	76.3	18.5	4.0	0.5	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
Akwa Ibom	78.8	13.9	5.5	0.9	0.5	0.0	0.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0
Anambra	76.2	20.9	1.9	0.5	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Bauchi	85.1	12.0	1.9	0.7	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Bayelsa	61.5	24.0	8.3	2.4	1.4	0.5	0.0	0.5	0.0	0.0	0.7	0.2	0.2	0.2
Benue	74.9	19.3	4.3	1.0	0.2	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0
Borno	73.5	22.0	2.7	1.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cross River	75.8	18.3	4.7	0.9	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Delta	62.2	29.3	6.2	1.5	0.4	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1
Ebonyi	88.9	10.1	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Edo	62.6	29.2	6.4	1.2	0.4	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Ekiti	81.1	14.3	2.6	1.0	0.6	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0
Enugu	80.7	13.1	3.9	0.8	0.6	0.2	0.1	0.1	0.0	0.2	0.3	0.0	0.0	0.0
Gombe	60.1	30.3	7.1	1.4	0.7	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Imo	72.2	21.1	4.7	1.3	0.4	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Jigawa	86.4	9.3	2.2	0.8	0.8	0.0	0.2	0.3	0.0	0.0	0.1	0.0	0.0	0.0
Kaduna	80.4	14.7	3.0	1.1	0.4	0.2	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.1
Kano	69.7	24.1	4.3	1.1	0.3	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0
Katsina	92.8	5.7	0.8	0.2	0.3	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Kebbi	80.1	14.9	3.1	1.0	0.4	0.2	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.1
Kogi	***76.1***	***17.8***	***3.9***	***0.7***	***1.5***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***
Kwara	84.6	13.3	1.3	0.4	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lagos	46.8	31.1	10.9	3.8	2.7	1.2	0.2	1.0	0.3	0.1	1.6	0.4	0.0	0.0
Nassarawa	71.3	18.2	6.3	1.7	1.0	0.3	0.2	0.6	0.1	0.0	0.2	0.0	0.0	0.1
Niger	77.7	16.7	3.9	1.1	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Ogun	78.3	15.4	4.2	0.9	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Ondo	81.9	15.2	2.2	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Osun	80.5	16.0	2.7	0.1	0.3	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0
Oyo	73.3	21.3	4.2	0.6	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Plateau	77.1	18.0	3.3	0.9	0.2	0.4	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
Rivers	56.1	32.2	7.8	2.0	1.1	0.2	0.0	0.6	0.0	0.0	0.1	0.0	0.0	0.0
Sokoto	60.9	28.2	7.0	3.2	0.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Taraba	88.9	7.9	2.2	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Yobe	94.3	4.0	1.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zamfara	65.2	19.3	8.7	4.1	2.1	0.3	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
FCT	43.3	32.9	12.4	6.3	2.7	0.5	0.1	0.8	0.5	0.1	0.4	0.0	0.0	0.0
Sector														
Urban	62.3	24.5	7.5	2.6	1.6	0.3	0.1	0.4	0.1	0.1	0.4	0.1	0.0	0.0
Rural	***79.6***	***15.9***	***3.2***	***0.8***	***0.3***	***0.1***	***0.0***	***0.1***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***
National	75.2	18.1	4.3	1.3	0.6	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0

Source: National Bureau of Statistics (Nigeria)-Annual Abstract of Statistics (2010)

3. Percentage Distribution of Households by Type of Fuel for Cooking, 2007, 2008 & 2009

State	Electricity			Gas			Kerosene			Wood			Coal		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Abia	-	0.2	-	0.7	0.7	2.2	25.8	21.4	21.8	73.6	77.8	75.9	-	-	0.2
Adamawa	0.5	0.2	-	-	0.4	-	6.2	2.3	5.0	93.4	96.8	95.0	-	0.4	-
Akwa Ibom	-	-	-	0.2	1.5	0.7	18.3	15.7	14.6	81.0	82.4	84.7	0.4	0.3	-
Anambra	0.4	-	-	0.3	0.7	0.5	26.8	21.7	27.9	72.2	77.3	71.6	0.3	0.2	-
Bauchi	0.0	-	0.2	-	0.2	-	2.1	1.6	2.8	97.6	98.2	97.0	0.3	-	-
Bayelsa	0.9	0.8	-	-	0.4	1.7	41.3	47.5	37.5	57.6	51.4	60.8	0.2	-	-
Benue	-	0.2	9.9	0.4	-	10.3	3.1	2.8	5.3	94.5	96.5	74.5	2.0	0.5	-
Borno	-	-	-	-	-	-	1.3	2.1	0.2	98.4	94.3	99.8	0.3	3.6	-
Cross Rivers	-	-	0.6	0.2	0.2	-	19.6	13.6	16.6	79.8	86.3	82.5	0.3	-	0.4
Delta	-	0.3	0.4	1.6	1.2	0.6	21.3	36.6	45.9	76.6	61.6	53.1	0.5	0.2	
Ebonyi	0.1	-	-	0.8	-	0.2	9.2	6.9	14.3	90.0	93.1	85.3	0.0	-	0.3
Edo	2.1	0.2	-	0.1	-	2.1	18.6	25.5	44.0	78.7	74.3	53.9	0.5	-	
Ekiti	-	0.7	0.5	-	0.3	0.4	24.2	36.6	44.5	74.3	61.5	52.6	1.5	0.9	2.0
Enugu	0.1	0.2	-	2.1	0.7	3.3	28.3	21.3	26.7	68.9	77.3	69.9	0.6	0.5	0.2
Gombe	2.1	0.3	-	0.0	-	-	5.5	3.6	3.5	92.4	95.9	96.5	0.0	0.2	-
Imo	0.2	0.5	-	0.7	1.0	0.3	13.6	7.4	11.5	85.1	90.9	86.7	0.4	0.2	1.5
Jigawa	1.0	0.2	-	-	0.3	-	3.9	1.6	0.6	95.1	97.8	99.4	0.0	0.2	-
Kaduna	0.3	0.2	0.3	1.2	-	-	9.8	8.7	10.3	88.5	90.7	89.4	0.2	0.5	-
Kano	1.3	0.5	0.3	0.1	0.2	0.5	3.4	4.5	7.9	94.9	94.1	90.8	0.3	0.7	0.5
Katsina	1.7	-	-	-	-	-	0.5	2.2	0.7	97.5	97.8	99.1	0.2	-	0.1
Kebbi	0.5	0.2	0.4	0.2	0.4	-	0.0	4.8	0.3	99.2	94.6	99.2	0.1	-	-
Kogi	***0.3***	***1.0***	***-***	***-***	***0.3***	***0.8***	***12.0***	***18.9***	***24.7***	***86.6***	***79.6***	***74.0***	***1.0***	***0.2***	***0.5***
Kwara	1.1	-	1.6	-	0.2	0.2	15.5	12.7	14.9	62.0	74.3	66.1	21.4	12.7	17.2
Lagos	2.8	-	1.1	3.8	6.2	2.2	89.7	91.1	87.6	3.1	2.7	8.7	0.6	-	0.4
Nassarawa	0.0	0.5	-	-	-	1.5	9.2	7.9	16.1	90.8	91.1	79.5	0.0	0.5	2.8
Niger	0.7	-	0.1	-	0.2	0.1	5.2	9.6	6.7	92.9	89.3	88.9	1.2	0.9	4.1
Ogun	2.0	-	0.7	-	0.7	0.9	48.8	60.9	73.8	49.0	37.3	24.6	0.3	1.2	-
Ondo	0.2	0.2	0.6	0.2	0.3	-	32.6	17.0	23.7	66.7	82.5	74.4	0.3	-	1.3
Osun	0.8	1.2	0.8	0.2	-	0.4	27.1	45.7	51.7	56.0	49.6	42.0	15.9	3.5	5.1
Oyo	0.1	-	-	1.3	0.5	0.6	44.7	43.6	58.8	50.2	44.1	35.4	3.8	11.8	5.2
Plateau	0.6	0.2	0.3	0.4	1.0	-	16.8	10.0	17.3	80.8	88.8	82.4	1.4	-	-
Rivers	-	0.3	-	2.8	1.7	3.1	31.3	38.9	50.7	65.2	59.1	46.2	0.7	-	-
Sokoto	0.6	0.2	-	0.3	-	0.2	2.5	6.3	3.1	96.2	93.5	96.6	0.5	-	-
Taraba	-	-	-	-	-	0.3	1.0	2.6	3.2	98.8	97.4	96.3	0.2	-	0.1
Yobe	-	-	0.1	-	-	-	0.9	2.3	0.8	98.7	97.7	98.8	0.4	-	0.3
Zamfara	0.1	-	-	0.1	-	-	4.1	1.7	0.4	95.5	98.3	99.6	0.3	-	-
FCT	0.7	0.2	0.7	3.4	1.9	6.0	34.5	38.7	30.7	57.4	57.6	60.3	4.0	1.7	2.2
Sector		-	-		-	-		-	-		-	-		-	-
Urban	1.5	0.5	0.5	2.0	1.8	2.0	54.1	49.6	55.3	39.0	44.9	40.6	3.4	3.1	1.6
Rural	***0.3***	***0.1***	***0.3***	***0.1***	***0.1***	***0.3***	***7.0***	***7.3***	***11.9***	***92.0***	***92.1***	***87.1***	***0.6***	***0.4***	***0.3***
National	0.7	0.2	0.4	0.7	0.6	0.9	22.9	18.5	27.5	74.1	79.6	70.4	1.6	1.1	0.8

Source: National Bureau of Statistics (Nigeria)-Annual Abstract of Statistics (2010)

4. Population Distribution of Regular Households by Type of Main Lighting Fuel – National, 2006

State	Total	Type of Main Lighting Fuel					
		Electricity	Gas	Kerosene	Candle	Solar	Other
Abia	605,987	229,595	5,248	359,734	8,279	830	2,301
Adamawa	184,468	111,189	4,015	43,541	17,617	2,280	5,826
Akwa Ibom	857,436	204,488	5,290	630,326	13,247	1,250	2,835
Anambra	882,875	395,337	18,040	429,719	33,755	2,983	3,041
Bauchi	847,731	142,679	9,845	659,987	28,659	2,805	3,756
Bayelsa	352,025	67,714	5,449	268,734	7,971	368	1,789
Benue	801,833	120,688	6,638	636,434	30,399	2,395	5,279
Borno	787,274	170,339	9,321	568,782	23,844	4,261	10,727
Cross River	645,251	187,968	2,563	443,676	7,688	884	2,472
Delta	890,312	368,099	10,448	475,999	30,041	1,745	3,980
Ebonyi	449,709	52,524	3,945	377,164	11,525	1,606	2,945
Edo	701,073	442,713	7,775	233,114	13,175	1,704	2,592
Ekiti	493,739	178,549	5,729	289,173	16,212	1,775	2,301
Enugu	725,767	256,050	9,676	435,339	20,122	1,879	2,701
Gombe	419,226	114,925	4,201	286,539	9,899	1,218	2,444
Imo	837,195	247,406	12,858	543,628	28,736	1,961	2,606
Jigawa	810,310	130,908	9,063	612,804	48,382	4,826	4,327
Kaduna	1,115,974	392,439	13,889	679,939	19,390	3,948	6,369
Kano	1,603,335	446,968	31,012	1,022,096	85,354	9,148	8,757
Katsina	1,066,316	249,776	14,842	735,408	54,435	5,981	5,874
Kebbi	562,827	142,966	7,774	386,250	21,729	1,809	2,299
Kogi	641,556	246,856	6,697	375,072	9,665	1,189	2,077
Kwara	468,780	261,917	4,260	189,004	9,725	1,426	2,448
Lagos	2,195,842	1,891,540	17,618	240,355	34,462	2,635	9,232
Nasarawa	342,711	79,375	4,261	247,708	8,098	1,074	2,195
Niger	729,964	266,035	6,632	442,629	10,174	1,472	3,022
Ogun	880,970	559,615	6,919	288,637	17,732	2,006	6,061
Ondo	763,020	320,930	5,884	414,613	17,059	1,467	3,067
Osun	730,313	407,657	6,914	294,408	14,232	2,045	5,057
Oyo	1,248,105	612,293	11,348	586,229	27,548	3,501	7,186
Plateau	604,491	132,216	3,655	442,132	16,993	2,226	7,269
Rivers	1,123,998	437,765	18,151	638,052	21,781	1,887	6,362
Sokoto	688,710	154,261	8,389	498,111	20,423	3,330	4,196
Taraba	431,385	27,017	3,367	379,517	17,044	1,215	3,225
Yobe	418,999	78,032	4,277	311,285	17,239	2,588	5,578
Zamfara	493,106	11,070	8,051	440,489	27,531	2,851	3,114
FCT(Abuja)	303,592	183,528	3,035	104,026	9,838	461	2,704
Nigeria	27,706,205	10,323,427	317,079	16,010,653	810,003	87,029	158,014

Source: National Bureau of Statistics

5. Percentage Distribution of Household by Type of Electricity Supply, 2009

State	Electricity Supply						Percent
	PHCN (NEPA) only	IPP/Rural Electrification only	Private Generator only	PHCN (NEPA)/Generator	IPP/Rural Electrification/ Generator	Solar Panels	None
Abia	46.2	-	9.0	20.0	0.1	-	24.6
Adamawa	13.8	-	4.4	1.7	-	0.4	79.7
Akwa Ibom	38.2	0.8	10.2	6.2	0.6	-	44.1
Anambra	81.0	-	-	6.1	-	-	12.8
Bauchi	38.7	0.1	0.5	6.2	-	-	54.5
Bayelsa	6.6	25.7	13.2	0.6	23.8	0.3	29.8
Benue	16.0	19.5	1.7	0.7	-	-	62.0
Borno	17.3	-	3.3	0.4	-	-	79.0
Cross River	38.7	5.4	6.4	7.4	-	-	42.0
Delta	48.1	3.4	2.5	6.6	0.6	-	38.9
Ebonyi	35.0	-	2.9	1.4	-	-	60.7
Edo	84.8	1.1	0.8	6.2	-	-	7.0
Ekiti	77.9	-	-	4.1	-	-	18.0
Enugu	41.3	3.0	4.1	8.0	1.6	-	41.9
Gombe	35.9	-	0.4	0.8	-	0.5	62.4
Imo	69.0	-	1.8	17.7	1.0	0.3	10.1
Jigawa	32.0	-	-	0.1	-	-	67.9
Kaduna	43.4	1.1	3.8	2.7	0.3	0.3	48.4
Kano	43.8	-	1.8	3.2	0.5	-	50.6
Katsina	41.6	-	0.4	0.6	-	-	57.4
Kebbi	37.8	-	0.9	6.3	0.4	-	54.6
Kogi	54.8	-	3.4	2.4	3.2	0.2	35.9
Kwara	70.7	-	4.0	1.6	-	-	23.7
Lagos	54.3	0.2	1.3	36.2	1.9	-	6.1
Nasarawa	17.7	-	16.8	13.0	0.8	-	51.8
Niger	33.4	-	2.2	0.9	1.3	-	62.3
Ogun	71.6	-	0.9	10.6	-	-	16.8
Ondo	54.5	-	5.4	8.6	-	-	31.4
Osun	75.0	-	2.3	1.7	-	-	21.0
Oyo	46.1	-	10.1	18.2	-	-	25.6
Plateau	25.0	2.2	4.7	2.3	1.2	-	64.6
Rivers	24.2	13.0	13.4	19.4	0.9	-	29.2
Sokoto	19.3	0.5	0.6	13.6	0.3	-	65.7
Taraba	15.3	0.1	2.1	1.1	-	-	81.3
Yobe	24.3	0.9	0.1	0.9	-	-	73.7
Zamfara	35.6	-	-	-	-	-	64.4
FCT	33.3	-	5.2	22.1	1.0	-	38.4
Sector							
Urban	72.0	1.1	1.6	14.9	0.7	-	9.6
Rural	39.6	2.1	3.8	3.4	1.1	0.1	49.9
National	51.3	1.7	3.0	7.6	1.0	-	35.3

Source: National Bureau of Statistics

6. Percentage distribution of households by state and electricity supply, 2007 and 2008

	PHCN Only		Rural Electrification Only		Private Generator Only		PHCN/Generator		Rural Electrification/ Generator		Solar energy		None	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Abia	44.5	45.7	0.1	1.3	5.9	6.5	15.2	13.5	0.5	1.8	0	0	33.8	31.1
Adamawa	22.3	22.6	0	0	1	3.4	4.9	3.9	0.5	0.4	0	0	71.4	69.8
AkwaIbom	46.3	40.6	2.7	1.7	3.3	7.9	7.6	5.9	1.9	0.2	0	0.2	38.3	44.6
Anambra	58	61.9	4.1	0	0.2	3	6.8	7.9	0	2.3	0	0	30.9	24.4
Bauchi	38.7	31.4	0	5.3	0	0	2.8	3.2	0	0	0	0	58.5	60.2
Bayelsa	10.3	21.6	10.1	23.3	13.3	8.6	5.8	7.5	37.8	12.2	0.5	0	22.2	36.9
Benue	15.7	22.8	0	0	2.8	4.2	2.5	0.9	0.5	0.2	0	0	78.6	72
Borno	19.4	15.2	4.6	0	10.6	3.8	0.9	3.6	0.1	0	0	0.2	64.5	77.3
C/River	54.1	40.6	0.5	0.3	3.2	3.4	1.7	9	3.4	0.3	0	0	37.1	46.3
Delta	62.7	56.8	0	0	2.5	2.9	3	7.5	1.6	3.1	0	0	30.2	29.6
Ebonyi	14.7	12.3	5	8.3	5	3.2	0.3	2.5	1.5	5.6	0	0	73.5	68.1
Edo	80.7	77.7	0	1.9	1.5	2	0.9	3.2	0	0	0.1	0	16.9	15.2
Ekiti	56.7	61	0	0	1.2	1.6	0.8	5.2	0	0.2	0	0	41.3	32.1
Enugu	45.6	44.9	0.2	0.5	3.6	3.6	5.5	4.8	0.3	0.3	0	0	44.8	45.8
Gombe	50.7	39.5	0	0.9	0	0.9	0	3.4	0	0	0	0	49.3	55.4
Imo	68.5	69.5	1.4	0.3	5.2	4.6	4.1	12.8	0.1	0.2	0	0	20.8	12.6
Jigawa	39.4	41.6	0	0.2	0.2	0.2	0.4	1.4	0	0.2	0	0	60	56.5
Kaduna	53.5	46.2	0.5	0.2	1.2	1.8	2.9	8.2	0.2	1.2	0	0	41.8	42.4
Kano	59.6	42.6	0	0	0	0.3	0.8	0.8	0	0	0	0	39.6	56.2
Katsina	31	36.2	0	1	0.1	0.2	6.8	2.9	0.2	0	0	0	62	59.7
Kebbi	44.2	42.7	0	0	1.5	0.4	1.7	2.5	0	0	0	0	52.6	54.4
Kogi	52.1	39.5	0	1.7	2.3	4.5	2.4	5.2	0.3	1	0	0	43	48.1
Kwara	54.9	56.4	0	0	1.5	1.5	4.7	3.6	0.5	0	0	0	38.3	38.5
Lagos	67.3	57	0.1	0	0.5	0.9	30.8	40.9	1.1	0.9	0	0	0.2	0.3
Nassarawa	27.7	21.3	0	0.2	2.2	2.4	6.2	3.6	0.4	1.9	0	0	63.6	70.6
Niger	42.5	35.6	0	0	0.3	6.2	1.4	1.6	0	0	0	0	55.9	56.6
Ogun	71.3	69.8	0.4	0	0.3	0.8	0.9	8.5	0.1	0.3	0	0	27.1	20.4
Ondo	58	50.3	0	1.7	4.3	3.8	3.4	2.2	5.3	0	0	0	29	41.9
Osun	67.6	63.6	1.6	0	0.3	1.2	0.5	1.4	0	0	0	0	29.9	33.9
Oyo	57.3	47.5	0.9	0	0.2	5.3	11.8	8.2	0	0.2	0	0	29.8	38.8
Plateau	23.8	18.8	2.4	1.4	3.3	5.7	3.8	2.1	1.1	0.7	0	0	65.6	71.3
Rivers	24.6	41	7.4	0.7	16.3	13.8	4.7	11.9	10.4	10.9	0	0	36.6	21.7
Sokoto	35.7	29.8	0.3	0	0.7	0.2	0.8	0.3	2.3	0.2	0	0	60.3	69.5
Taraba	3.7	2.8	0.7	0	2.4	1.2	1.7	5.9	0.3	1.4	0.1	0	91	88.8
Yobe	16.2	18.1	0.4	0.7	0.1	0.7	0.3	2.1	0.2	0.4	0	0	82.9	78
Zamfara	24.7	21.5	0	0.2	0.3	0.2	2.4	0.5	0	0	0	0.5	72.7	77.1
FCT	36.6	38.3	0	0.3	11.7	10.6	19.8	23.7	0.6	0.2	0	0	31.3	26.9
Average	47.3	40.4	1.1	0.9	2.7	3.2	5.8	6.3	1.6	1.1	0	0	41.4	48

Source: NBS/CBN/NCC Social-Economic Survey on Nigeria, 2008.

7. Evaluation criteria for selection of projects under rural electrification scheme in Nigeria

SN	CRITERIA	MAX. MARKS
A.	SATISFACTION OF FORMAL REQUIREMENTS:	20
i.)	Project applicant as a legal entity, (sponsors must establish a legally recognizable entity, e.g. a co-operative or a company)	5
ii.)	Investment items for which support is being sought are eligible for support according to the published conditions	5
iii.)	All application forms have been properly completed	5
iv.)	Copies of the feasibility study and business plan have been attached	5
B.	COMPLIANCE WITH REGULATORY C	20
i.)	All needed local planning approvals have been obtained	10
ii.)	Performance of Environmental impact Assessment (EIA), where necessary	5
iii.)	A license has been properly issued for the projects, or at a minimum the license application is at a processing stage. If so, acknowledgement of receipt of the application for the license has been issued	5
C.	COMPLIANCE WITH TECHNICAL CONDITIONS:	30
i.)	Fulfillment of minimum technical standards in the feasibility study (this is a criterion for the license and is subject to inspection by REA)	15
ii.)	Cost of individual major investment items are in line with the level of local costs according to the data base maintained by REA	10
iii.)	Evidence of rural community/beneficiary participation in design of	5

	project and implementation subsequently	
D.	FINANCIAL VIABILITY OF THE PROJECT:	15
i.)	Strong evidence of financial capacity and current 3 years Audited Accounts	2.5
ii.)	The required debt financing for the project have been secured (copies of the draft loan agreement and the bank's project appraisal documents have been attached)	5
iii.)	Low cost Rural Electrification technology options have been utilized in the project design where possible	2.5
iv.)	Evaluation of REF confirms the bank's assessment of financial viability and ability of the project's cash flow in 1st 5years to service debt payments.	5
E.	INSTITUTIONAL VIABILITY OF THE PROJECT:	5
i.)	Evidence that project demonstrates local community support	2.5
ii.)	Evidence of State/Rural Electricity Board and Local Govt participation in project	2.5
F.	QUALIFICATIONS/EXPERIENCE OF PROJECT TEAM PLAYERS	10
i.)	Project Team Key personnel qualifications	5
iI.)	Project Team key personnel experience in similar projects	5
	TOTAL MARKS	100

Source: Draft Rural Electrification Strategy and Implementation Plan 2012

8. New Retail Tariff Classes and Description under MYTO II

s/no	Customer classification	Description	Remarks
1	Residential		A consumer who uses his premises exclusively as a residence-house, flat or multi-storeyed house where people reside
	R1	Life-Line (50kWh)	
	R2	Single and 3-phase	
	R3	LV Maximum Demand	
	R4	HV Maximum Demand (11/33 KV)	
2	Commercial		A consumer who uses his premises for any purpose other than exclusively as a residence or as a factory for manufacturing goods
	C1	Single and 3-phase	
	C2	LV Maximum Demand	
	C3	HV Maximum Demand (11/33 KV)	
3	Industrial		A consumer who uses his premises for manufacturing goods including welding and ironmongery
	D1	Single and 3-phase	
	D2	LV Maximum Demand	
	D3	HV Maximum Demand (11/33 KV)	
4	Special		Customers such as agriculture (agro-allied enterprises involving processing are executed), water boards, religious houses, Government and teaching hospitals, Government research institutes and educational establishments.
	A1	Single and 3 Phase	
	A2	LV Maximum Demand	
	A3	HV Maximum Demand (11/33KV)	
5	Street Lighting		
	S1	Single and 3-phase	

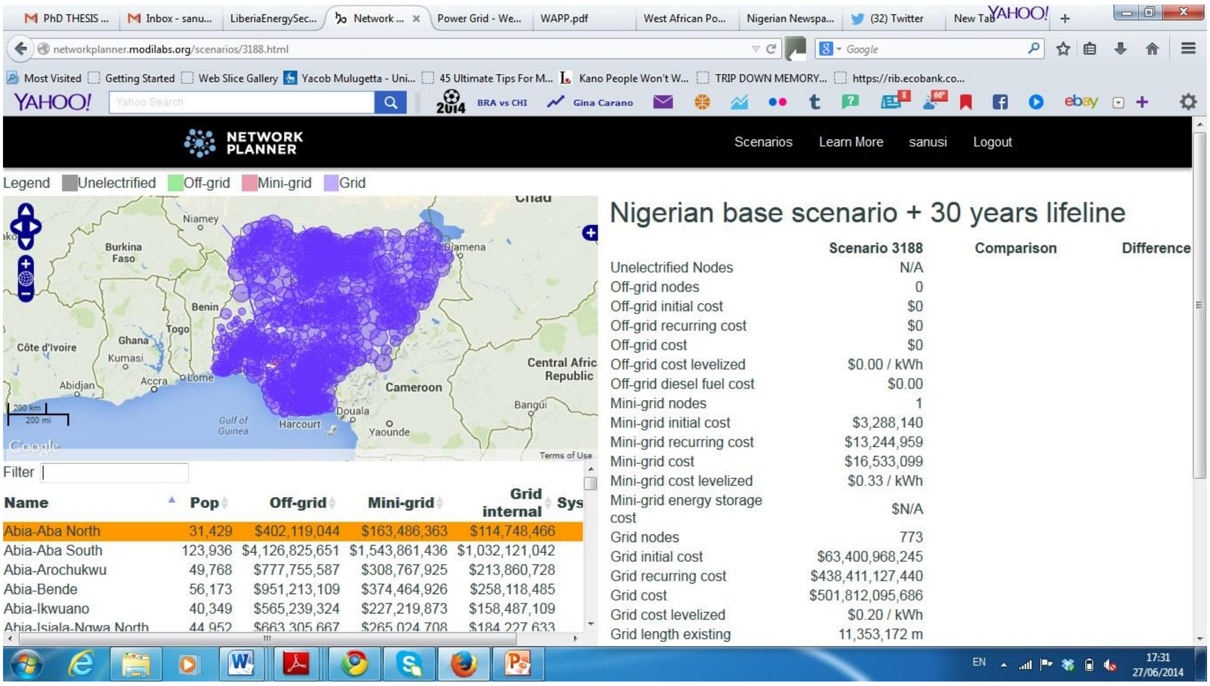
Source: NERC Website

9. FGN Tariff Subsidies for R1 and R2 customers paid to various DisCos in 2012 and 2013

Discos	Tariff Class	Cost of Service- =N=/Kwh	Recovered from customers- =N=/Kwh	Subsidy- =N=/Kwh	Total Subsidy -=N= Million
		2012 (2013)	**2012 (2013)**	**2012 (2013)**	**2012 (2013)**
ABUJA	R1	21.72 (20.46)	4.00 (4.00)	17.72 (16.46)	43.77 (40.80)
	R2	21.72 (20.46)	11.96 (12.58)	9.76 (7.61)	5,706.23 (5,709.20)
	Sub-Total				**5,750.00 (5,750.00)**
BENIN	R1	22.40 (20.89)	4.00 (4.00)	18.40 (16.89)	8.48 (8.21)
	R2	22.40 (20.89)	11.69 (11.73)	10.72 (9.16)	4,491.52 (4,491.79)
	Sub-Total				**4,500.00 (4,500.00)**
ENUGU	R1	22.23 (20.80)	4.00 (4.00)	17.85 (16.80)	1.13 (1.01)
	R2	22.23 (20.80)	13.08 (15.01)	9.15 (5.79)	4,498.87 (4,498.99)
	Sub-Total				**4,500.00 (4,500.00)**
IBADAN	R1	23.73 (22.01)	4.00 (4.00)	19.73 (18.01)	39.97 (39.33)
	R2	23.73 (22.01)	12.83 (13.42)	10.09 (8.59)	6,460.00 (6,460.67)
	Sub-Total				**6,500.00 (6,500.00)**
JOS	R1	23.19 (21.64)	4.00 (4.00)	19.19 (17.64)	22.31 (22.33)
	R2	23.19 (21.64)	16.66 (16.65)	6.53 (4.9932)	2,727.69 (2,727.67)
	Sub-Total				**2,750.00 (2,750.00)**
KADUNA	R1	23.50 (21.76)	4.00 (4.00)	19.76 (17.76)	1.88 (1.70)
	R2	23.50 (21.76)	13.31 (14.65)	10.19 (7.10)	3,998.12 (3,998.30)
	Sub-Total				**4,000.00 (4,000.00)**
KANO	R1	21.43 (20.24)	4.00 (4.00)	17.43 (18.94)	68.70 (65.91)
	R2	21.43 (20.24)	13.04 (13.68)	8.39 (6.56)	3,931.30 (3,934.09)
	Sub-Total				**4,000.00 (4,000.00)**
EKO	R1	22.01 (20.82)	4.00 (4.00)	16.82 (16.82)	0.01 (0.01)
	R2	22.01 (20.82)	13.10 (13.13)	7.69 (7.69)	5,499.99 (5,499.99)
	Sub-Total				**5,500.00 (5,500.00)**
IKEJA	R1	20.09 (19.40)	4.00 (4.00)	15.40 (15.40)	0.39 (0.39)
	R2	10.09 (19.40)	12.68 (13.08)	7.41 (6.32)	7,499.61 (7,499.61)
	Sub-Total				**7,500.00 (7,500.00)**
PORTHARCOURT	R1	22.70 (21.19)	4.00 (4.00)	18.70 (17.19)	1.28 (1.37)
	R2	22.70 (21.19)	16.39 (16.83)	6.31 (4.36)	3,248.44 (3,248.44)
	Sub-Total				**3,250.00 (3,250.00)**
YOLA	R1	23.73 (21.99)	4.00 (4.00)	19.99 (17.99)	46.35 (42.33)
	R2	23.73 (21.99)	11.88 (12.80)	11.86 (9.19)	1,703.65 (1,707.67)
	Sub-Total				**1,750.00 (1,750.00)**

Source: NERC Website

APPENDIX 5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NETWORK PLANNER
Scenarios
Learn More
sanusi
Logout
Legend
Unelectrified
Off-grid
Mini-grid
Grid
Nigerian base scenario + 30 years lifeline
Scenario 3188
Comparison
Difference
Unelectrified Nodes N/A
Off-grid nodes 0
Off-grid initial cost $0
Off-grid recurring cost $0
Off-grid cost $0
Off-grid cost levelized $0.00 / kWh
Off-grid diesel fuel cost $0.00
Mini-grid nodes 1
Mini-grid initial cost $3,288,140
Mini-grid recurring cost $13,244,959
Mini-grid cost $16,533,099
Mini-grid cost levelized $0.33 / kWh
Mini-grid energy storage cost $N/A
Grid nodes 773
Grid initial cost $63,400,968,245
Grid recurring cost $438,411,127,440
Grid cost $501,812,095,686
Grid cost levelized $0.20 / kWh
Grid length existing 11,353,172 m
Filter
Name
Pop
Off-grid
Mini-grid
Grid internal
Sys
Abia-Aba North 31,429 $402,119,044 $163,486,363 $114,748,466
Abia-Aba South 123,936 $4,126,825,651 $1,543,861,436 $1,032,121,042
Abia-Arochukwu 49,768 $777,755,587 $308,767,925 $213,860,728
Abia-Bende 56,173 $951,213,109 $374,464,926 $258,118,485
Abia-Ikwuano 40,349 $565,239,324 $227,219,873 $158,487,109
Niamey
Burkina Faso
Benin
Togo
Ghana
Côte d'Ivoire
Kumasi
Abidjan
Accra
Lome
Cameroon
Central African Republic
Bangui
Douala
Yaounde
Harcourt
Gulf of Guinea
Chad
Ndjamena
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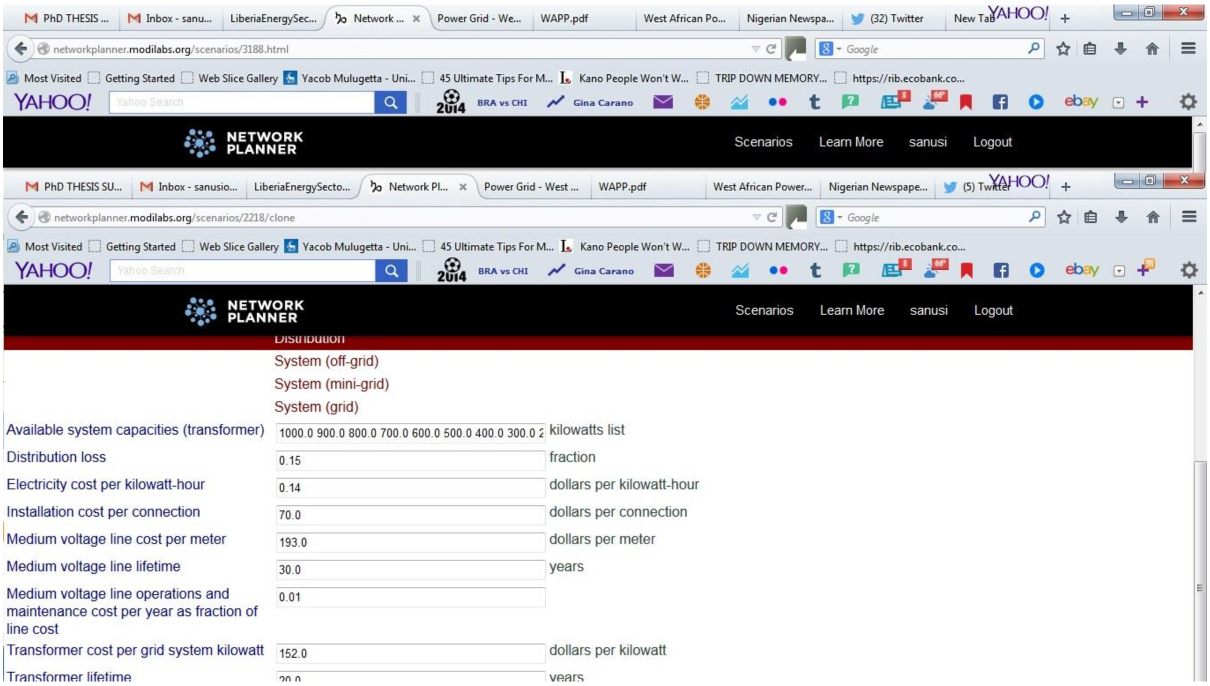
27/06/2014

Appendix 6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Scenarios
Learn More
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NETWORK PLANNER
Scenarios
Learn More
sanusi
Logout
System (off-grid)
System (mini-grid)
System (grid)
Available system capacities (transformer)
1000.0 900.0 800.0 700.0 600.0 500.0 400.0 300.0
kilowatts list
Distribution loss
0.15
fraction
Electricity cost per kilowatt-hour
0.14
dollars per kilowatt-hour
Installation cost per connection
70.0
dollars per connection
Medium voltage line cost per meter
193.0
dollars per meter
Medium voltage line lifetime
30.0
years
Medium voltage line operations and maintenance cost per year as fraction of line cost
0.01
Transformer cost per grid system kilowatt
152.0
dollars per kilowatt